shades of green

Nevada Division of Forestry
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CLEANER AIR, TREE BY TREE

A Best Management Practices Guide for Urban Trees in Southern Nevada

"As many Desert Southwest communities continue to grow during the next decade, sustaining healthy community forests becomes integral to the quality of life. The role of urban forests to enhance the environment, increase community attractiveness and livability, and foster civic pride is taking on greater significance.."

— Center for Urban Forest Research

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Damon Ohlerking

Because he loved life.
Because he loved the trees that
make life joyful.
Because he loved the people who
planted and cared for the trees.
Because he was our friend.
We dedicate this effort to the
memory of Damon Ohlerking.
- Helen M. Stone

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INTRODUCTION

This *Cleaner Air, Tree by Tree - A Best Management Practices Guide for Urban Trees in Southern Nevada* is the work of Nevada Shades of Green, a local committee of professional *arborists**, *landscape architects*, air quality specialists, city and county planners and educators. Because living in the desert poses additional challenges and difficulties for growing and maintaining trees, the practices and standards in this guide are adapted to our unique desert climate.

The purpose of this guide is to provide information on how trees improve communities and their environment, but more importantly, to provide guidelines and standards to be used when planning for trees and maintaining trees in urban landscapes in southern Nevada. It will serve as a model for citizens, local officials and developers on how to incorporate trees into the development process. Our goal is to provide standards that can be used to revise existing municipal ordinances concerning trees and landscaping, and as a result, increase our *urban forest* and the benefits it provides.

Since 1990, Clark County's population has grown by more than one million individuals, resulting in land use pressures. An increase in urban temperature is often associated with rapid urban growth; this increase in temperature is known as the *urban heat island* effect. Because emissions of some air pollutants increase with temperature, effective heat mitigation programs can improve air quality.

Planting, growing and maintaining a healthy *urban forest* is recognized by the Environmental Protection Agency (EPA) as one way in which urban heat can be abated. In 2004-2005, the EPA published policy and guidance documents that permit local agencies to incorporate air pollutant emission reductions within *state implementation plans*. The Clark County Community Task Force Report has listed poor air quality as a factor that could limit growth in Clark County. Implementing strategic tree planting measures, as one component of a comprehensive *urban heat island* effect mitigation program, can help protect the air resources of the County.

According to the Center for Urban Forest Research, "the role of *urban forests* to enhance the environment, foster civic pride, and increase community attractiveness, livability, and property values is taking on greater significance as communities strive to balance economic growth with environmental quality and social well-being."

*Italicized words throughout the document are defined in the glossary, or are publication titles.

The green infrastructure is a significant component of communities in Southern Nevada.
The District at Green Valley Ranch

CHAPTER ONE

Benefits of Urban and Community Forests

This guide emphasizes trees as an integral part of the community infrastructure. Studies prove that trees have a positive effect on many aspects of people's lives, including their health, homes, businesses, communities, drinking water, and air quality.

The information in chapter one is adapted from the *Desert Southwest Community Tree Guide: Benefits, Costs and Strategic Planning*, by Gregory E. McPherson et al.

Trees improve air quality

Urban trees provide air quality benefits in four main ways:

- Trees absorb gaseous pollutants (e.g., *ozone*, *nitrogen oxides*, and *sulfur dioxide*) through leaf surfaces.
- Trees intercept *particulate matter* (e.g., dust, ash, pollen, and smoke).
- Trees release oxygen through *photosynthesis*.
- Trees *transpire* water and shade surfaces, which lower local air temperatures, and contribute to reducing *ozone* levels.
    - *American Forest's* study of the Colorado Front Range area found that the existing 6% tree *canopy cover* annually removed 1,080 tons of air pollutants, a process valued at $5.3 million. A similar analysis for the Willamette/Lower Columbia Region reported that existing tree cover (24%) removed 89,000 tons of pollutants annually, a process valued at $419 million.
    - Trees in Davis, California parking lots reduced asphalt temperatures by as much as 36^{o} F, car interior temperatures by over 47^{o} F, and air temperatures by 1^{o}-3^{o} F. By shading asphalt surfaces and parked vehicles, the trees reduced *hydrocarbon* emissions from gasoline that evaporates out of leaky fuel tanks and worn hoses. These evaporative emissions are a component of *smog*, and parked vehicles are one source.

Trees save energy

Trees modify the climate and conserve building energy use in three principal ways:

- Shade from trees reduces the need for air conditioning in buildings and makes air temperatures outside cooler in the shade.

- Trees *transpire* – water absorbed by plants evaporates into the atmosphere from leaf surfaces – resulting in cooler air temperatures.
- Trees block winds and slow wind speed, reducing cold outside air from entering into buildings. This prevents heat loss and lessens the need for heating.
    - A computer simulation of annual cooling savings for an energy efficient home in Tucson, Arizona indicated that the typical household with air conditioning spent about $400 each year for cooling and $50 for heating. Shade and lower temperatures from three 25-ft tall trees, two on the west side of the house and one on the east, was estimated to save $100 each year for cooling, a 25% reduction.
    - Windbreaks reduce wind speed and resulting air infiltration by up to 50%, translating into potential annual heating savings of 10-12%.

Trees reduce atmospheric *carbon dioxide*

Urban forests can reduce atmospheric *carbon dioxide* in two ways:

- Trees *sequester carbon dioxide* as woody and foliar biomass.
- Trees near buildings reduce the demand for heating and air conditioning, thereby reducing emissions associated with electric power production.
    - Sacramento, California's 6 million trees remove approximately 335,000 tons of atmospheric *carbon dioxide* annually, with an implied value of $3.3 million.
    - In the above example, avoided power plant emissions (83,300 tons) accounted for 32% of the amount reduced.

Trees reduce stormwater runoff

A healthy *urban forest* can reduce the amount of runoff and pollutant loading in receiving waters in four ways:

- Leaf and branch surfaces intercept and store rainfall, thereby reducing runoff volumes and delaying the onset of peak flows.
- Root growth and soil fauna and root decomposition increase the capacity and rate of soil infiltration by rainfall and reduce overland flow.
- Tree canopies reduce soil erosion by diminishing the impact of raindrops on barren surfaces.
- *Transpiration* through tree leaves reduces soil moisture, increasing the soil's capacity to store rainfall.
    - A typical, medium-sized tree in coastal southern California was estimated to intercept 2,380 gallons of rainfall annually.
    - In the Colorado Front Range, existing *canopy cover* (6%) was estimated to reduce runoff by 52.9 million ft^3, valued at $3.2 million annually. In the Willamette/Lower Columbia region, existing *canopy cover* (24%) reduced runoff by 8.5 billion ft^3. The annualized value of this benefit was $140 million.

Trees provide aesthetic, social, economic and health benefits

One of the most frequently cited reasons that people plant trees is for beautification, but there are a lot of other good reasons to have trees in our cities.

- Trees provide shade!
- Trees add color, texture, line, and form to the landscape and soften the hard geometry that dominates built environments.
- Landscaping, especially with trees, can significantly increase property values. Example: A value of $15,000 (9% of property value) was determined in a U.S. Tax Court case for the loss of a large black oak on a property valued at $164,500.
- Research on hospitalized patients with views of nature and time spent outdoors has shown that they need less medication, sleep better, and have a better outlook than patients without connections to nature.
- Research on the aesthetic quality of residential trees has shown that *street trees* are the single strongest positive influence on scenic quality.
- Recent research has also shown, trees can contribute to reduced levels of domestic violence, as well as foster safer and more sociable neighborhood environments.
- * Research has shown that shoppers in well-landscaped business districts are willing to pay more for parking and up to 12% more for goods and services.
- * In a Chicago study, trees were shown to reduce crime. Apartment buildings with high levels of greenery had 52% fewer crimes than those without any trees. Buildings with medium amounts of greenery had 42% fewer crimes.

* This information is from *USDA Forest Service Publication NA-IN-02-04.*

CHAPTER TWO

Best Management Practices for Tree Selection and Location

Chapter two draws heavily from the work of Best Management Practices for Community Trees: A Technical Guide to Tree Conservation in Athens-Clarke County, Georgia.

Parking Lots

Although the parking lot is a difficult environment for trees, successful conservation and planting in parking lots can be achieved through proper species selection, site design, soil consideration and good maintenance.

Trees in parking lots contribute the following benefits:

- Provide shade and cooling to people, vehicles, and pavement
- Improve air quality and reduce the amount of *volatile organic compounds (VOCs)* given off by parked cars
- Reduce glare and reflection from sunlight
- Beautify the landscape
- Reduce stormwater runoff
- Screen parking areas from roadways and adjacent properties

Species Selection

- Consider planting low *biogenic volatile organic compound (BVOC)* emitting trees.
- Choose trees that do not have sharp spines or thorns and do not drop an excessive amount of fruit, limbs, or leaves.
- Plant moderate to fast growing trees to realize shading benefits as soon as possible. Parking lots and the trees in them often have short life spans.
- Select species that tolerate reflected heat and poor soil conditions.
- Match the species mature size to the available growing space; plant trees with as large a *canopy* as possible. The use of trees with little or no *canopy* is discouraged.
- If palm trees are desired, use them as accent trees in groups near parking lot entrances. Do not use them in the interior of the parking lots, as they provide minimal shade.
- When planting rows of trees include a variety of species to avoid *monocultures* and noticeable gaps after dead or injured trees are removed and a smaller tree is replanted.
- See Appendix A – Recommended Tree Species for additional information.

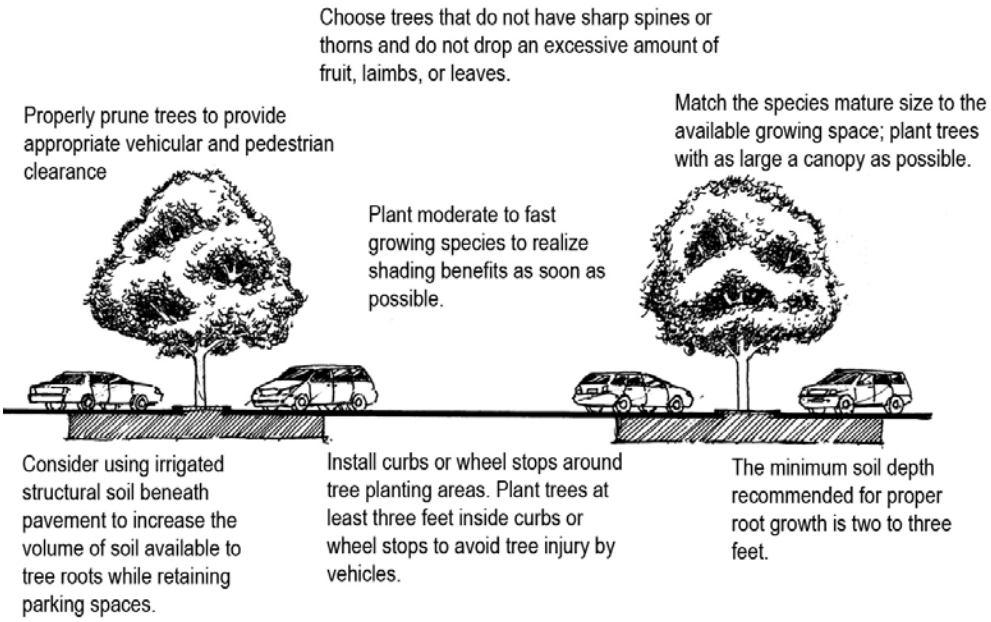
Soil Considerations

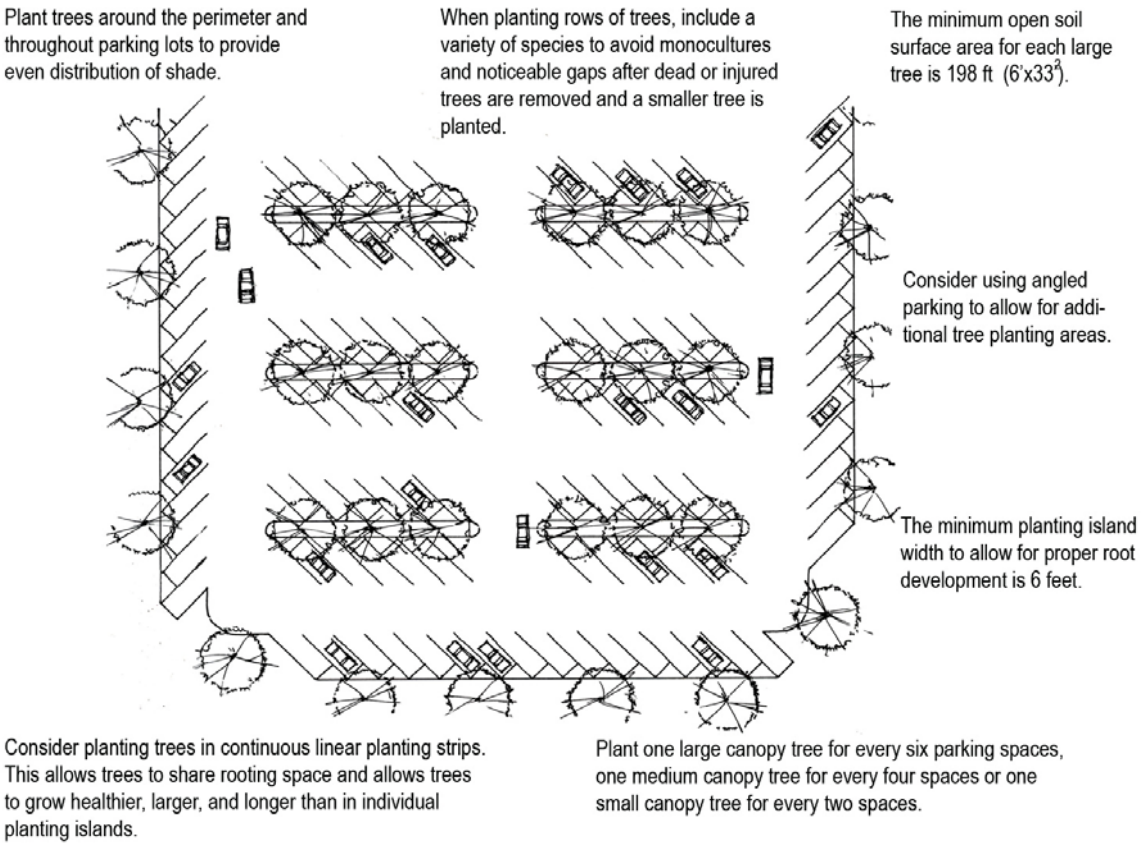
- Providing adequate soil volume for healthy root growth is the critical factor for successfully growing healthy trees in parking lots.
- Ideally, enough exposed soil surface area should be provided to allow the roots to grow at least to the *dripline* of a mature tree. However, a larger planting area for trees means fewer parking spaces available; therefore, a minimum open soil surface area has been established for trees in parking lots. See Table 1.
- The minimum *planting island* width to allow proper root development is six feet.
- The minimum soil depth recommended for proper root growth is two to three feet. See Appendix D – Soil Volume for additional information.

Recommended Tree Species Size Categories	Average Canopy Size	Minimum Open Soil Surface Area (Per Tree)	Minimum Open Soil Surface Area For Planting Strips (Per Tree)
Small	16 ft x 16 ft	81 ft^2 (9 ft x 9 ft)	84 ft^2 (6 ft x 14 ft)
Medium	22 ft x 22 ft	121 ft^2 (11 ft x 11 ft)	120 ft^2 (6 ft x 20 ft)
Large	28 ft x 28 ft	196 ft^2 (14 ft x 14 ft)	198 ft^2 (6 ft x 33 ft)

Table 1. Minimum Open Soil Surface Area for Parking Lots

- Consider planting trees in linear planting strips combined with an enlarged planting area on the end. This allows trees to share rooting space and allows trees to grow healthier, larger, and longer than in individual *planting islands*.
- Consider using *structural soil* beneath the pavement to increase the volume of soil available to tree roots while retaining parking spaces. See Appendix C – Structural Soil for additional information.
- Consider using *pervious concrete* or pavers in combination with *structural soil*. *Pervious concrete* and pavers accommodate pedestrians and vehicles, allow for increased moisture flow to tree roots, and allow for gas exchange between the roots and soil surface. See Appendix B – Pervious Concrete for additional information.
- Avoid planting trees in confined areas, such as small *planting diamonds*, because they don't provide enough soil volume for healthy and sustainable tree growth.
- Remove construction debris from planting pits and backfill with quality soil.





Design Considerations

- A combination of *planting islands*, *pervious concrete*, and *structural soil* beneath pavement will create more sustainable growing spaces for trees in parking lots.
- Plant trees around the perimeter and throughout parking lots to provide even distribution of shade.
- Plant one large *canopy* tree for every six parking spaces, one medium *canopy* tree for every four parking spaces, or one small *canopy* tree for every two parking spaces.
- Provide understory plantings to ensure trees receive adequate irrigation. See Tree Maintenance section for additional information about irrigation.
- Installation of *root barriers* along sidewalks and curbs will reduce tree roots from heaving and breaking pavers, sidewalks, curbs, and road pavement.
- Increase the ratio of compact to full-sized spaces, and use one-way aisles, angled parking spaces, and shared parking to allow for additional tree planting areas. Plant trees only where there is adequate room, both overhead and underground, for the mature size of the tree being planted.

- Reduce conflicts between trees, lighting, power lines, and signage by coordinating location of trees, light poles, and signs.
    - Shorten the maximum height of parking lot poles to the height trees are typically pruned for clearance.
    - Amend sign ordinances to allow monument signs (eye-level signs located near the street) and promote site designs that locate businesses closer to the street and move parking behind the buildings.
- Install curbs or wheel stops around tree planting areas. Plant trees at least three feet inside curbs or wheel stops to avoid tree injury by vehicles.
- Provide bicycle parking racks to reduce the practice of locking bikes to tree *trunks*.
- Consider installing uncurbed tree *planting islands* in the form of swales or linear shallow depressions which serve to filter and absorb stormwater runoff.

Maintenance

- Replace dead or damaged trees with similar species. Do not remove a large *canopy* species and replace it with a small *canopy* species.
- Properly prune trees to provide appropriate vehicular and pedestrian clearance. See Tree Maintenance section for additional information about pruning.

The minimum planting island width to allow for proper root development is six feet. Hills Center North Business Park, Summerlin

Small planting diamonds do not provide enough soil volume for healthy and sustainable tree growth. Las Vegas

Public Facilities and Commercial Areas

Public facilities and commercial areas include schools, police stations, fire stations, libraries, plazas, downtown settings, and retail and commercial areas.

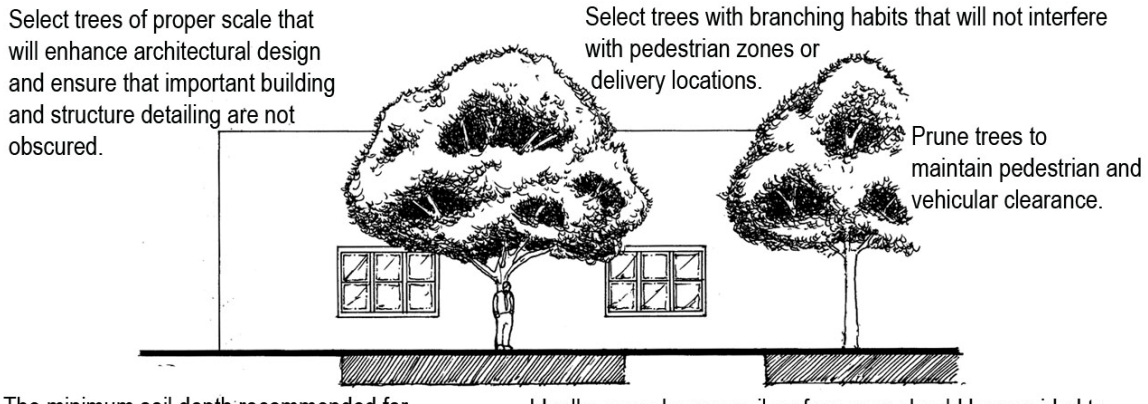
An abundance of pavement, poor quality and inadequate volume of soil, close proximity to buildings and streets, air pollution, and high levels of human activity are characteristic of these areas. These characteristics create challenging conditions for tree survival and management.

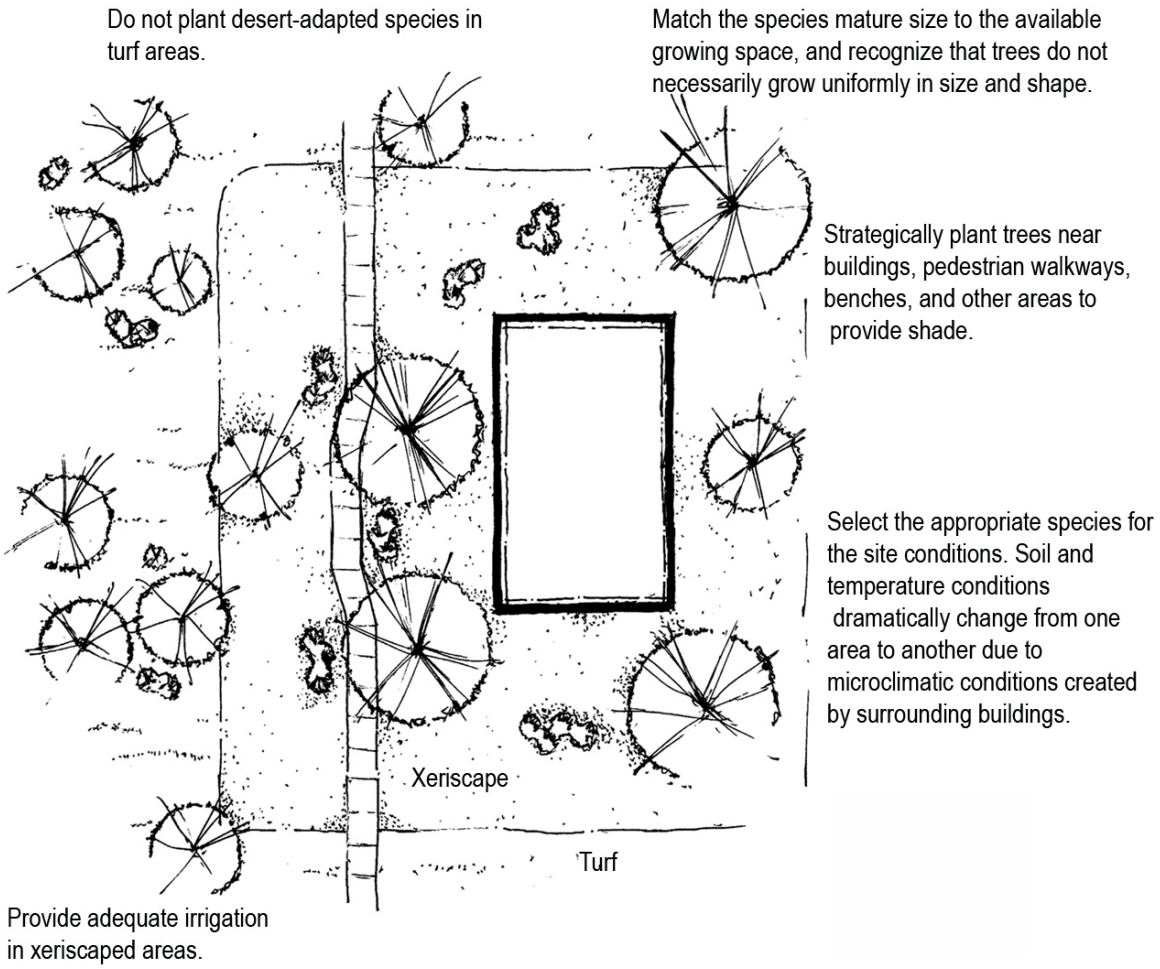
Trees in public facilities contribute the following benefits:

- Enhance *streetscape* and hardscape design
- Enhance architecture
- Provide shade and cooling
- Reduce glare and reflection from sunlight
- Provide a living component to built environments
- Attract people to the area

Species Selection

- Consider planting low *biogenic volatile organic compound (BVOC)* emitting trees.
- Choose trees that do not drop an excessive amount of fruit, limbs, or leaves.
- Select trees with branching habits that will not interfere with pedestrian zones or delivery locations.
- Match the species mature size to the available growing space, and recognize that trees do not necessarily grow uniformly in size and shape.
- Select trees of proper scale that will enhance architectural design and ensure that important building and structure detailing are not obstructed.
- Select the appropriate species for the site conditions. Soil and temperature conditions dramatically change from one area to another due to microclimatic conditions created by surrounding buildings.





- Do not plant desert-adapted species in turf areas.
- See Appendix A – Recommended Tree Species for additional information.

Soil Considerations

- Providing adequate soil volume for healthy root growth is the critical factor for successfully growing healthy trees in locations with large amounts of pavement. Ideally, enough exposed soil surface area should be provided to allow the roots to grow at least to the *dripline* of a mature tree.
- The minimum soil depth recommended for proper root growth is two to three feet. See Appendix D – Soil Volume for additional information.
- Consider using *structural soil* beneath the pavement to increase the volume of soil available to tree roots. See Appendix C – Structural Soil for additional information.

- Consider using *pervious concrete* or pavers in combination with *structural soil*. *Pervious concrete* and pavers accommodate pedestrians and vehicles, allow for increased moisture flow to tree roots, and allow for gas exchange between the roots and soil surface. See Appendix B – Pervious Concrete for additional information.

Design Considerations

- Strategically plant trees near buildings, pedestrian walkways, benches, and other areas to provide shade. Evergreen trees planted on the north side of buildings block prevailing winter winds and deciduous trees planted on the south and west sides of buildings provide shade during summer months.
- A combination of *planting islands*, *pervious concrete*, and *structural soil* beneath pavement will create more sustainable growing spaces for trees.
- Install *root barriers* along sidewalks and curbs and within *planting islands* to reduce damage to pavers and sidewalks by tree roots.
- Provide bicycle parking racks to reduce the practice of locking bikes to tree *trunks*.
- Locate trees away from aboveground and underground utilities. See Utility Corridors section for additional information.
- Provide adequate irrigation in xeriscape areas. See Tree Maintenance section for additional information about irrigation.

Maintenance

- Protect trees from vandalism and vehicular damage by using proper tree pruning methods (leaving lower branches discourages vandalism to the *trunk*) and by installing fencing or other barriers.
- Prune trees to maintain pedestrian and vehicular clearance. See Tree Maintenance section for additional information about pruning.

Research has shown that shoppers in well-landscaped business districts are willing to pay more for parking and up to 12% more for goods and services. The District at Green Valley Ranch

Research on hospitalized patients with views of nature and time spent out doors has shown that they need less medication, sleep better, and have a better outlook than patients without connections to nature.
Summerlin Medical Center

Large Landscaped Areas and Open Space

Open space areas include parks, golf courses, large landscaped areas around institutions, office and industrial parks, and rural areas. Trees occur individually and in small groups within large landscape areas, and usually have abundant growing space for their *trunk*, *crown*, and roots.

While some large landscape areas and the trees within them are intensively managed, such as on a golf course, others in open space and natural areas are relatively un-maintained.

Trees growing in large landscaped areas contribute the following benefits:

- Provide a natural setting for outdoor recreation and an urban connection to nature
- Beautify the regional landscape
- Promote environmental quality:
  - ✓ conserve soil and water
  - ✓ reduce stormwater runoff and water pollution
  - ✓ improve air quality and reduce air pollution
  - ✓ cool our communities and reduce energy usage
  - ✓ enhance wildlife habitat

Species Selection

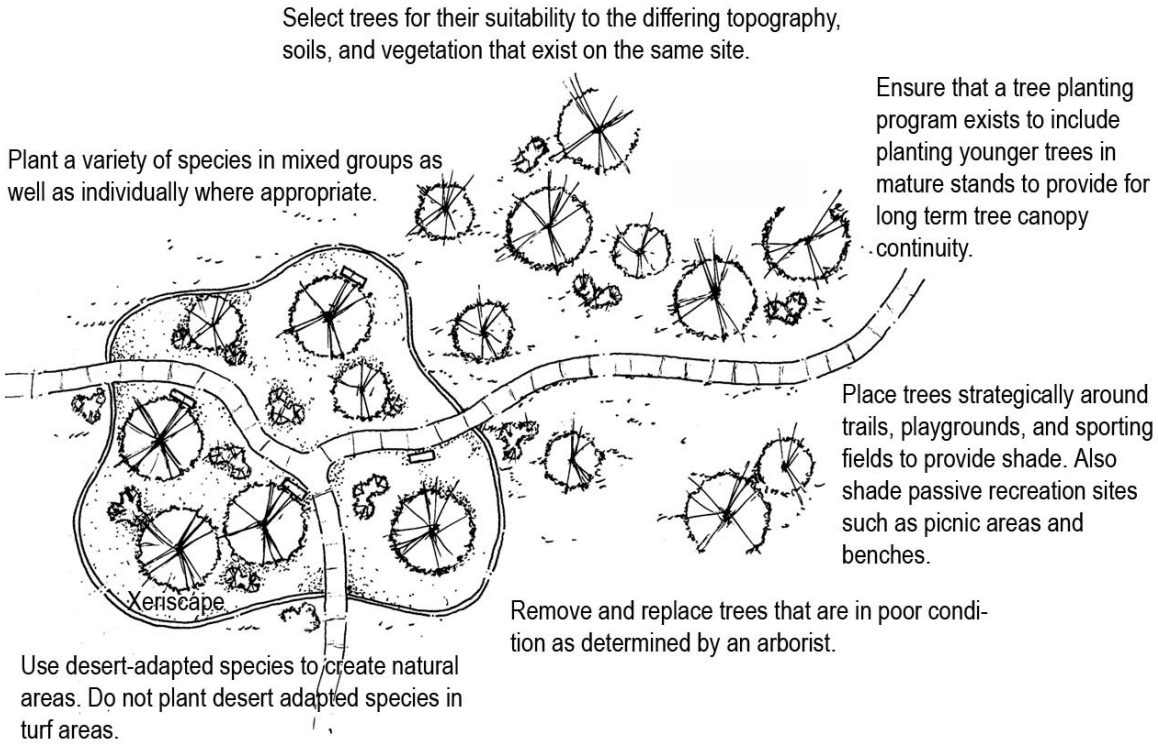
- Consider planting low *biogenic volatile organic compound (BVOC)* emitting trees.
- Plant a variety of species in mixed groups as well as individually where appropriate.
- Select trees for their suitability to the differing topography, soils, and vegetation that exist on the same site.
- Use desert-adapted species to create natural areas. Do not plant desert-adapted species in turf areas.
- See Appendix A – Recommended Tree Species for additional information.

Soil Considerations

- The minimum soil depth recommended for proper root growth is two to three feet. See Appendix D – Soil Volume for additional information.
- Prevent soil compaction by keeping vehicles out of the *dripline*. Restore aeration to compacted areas by *vertical mulching*.

Design Considerations

- Create tree islands with understory plants to enhance wildlife habitats or to prevent pedestrian foot traffic in unwanted areas.
- Plant trees strategically around trails, playgrounds, and sporting fields to provide shade. Also shade passive recreation sites such as picnic areas and benches.
- Provide adequate irrigation in xeriscape areas. See Tree Maintenance section for additional information about irrigation.



Maintenance

- Mulch around individual trees and throughout groupings of trees to improve soil conditions and conserve soil moisture. See Tree Maintenance section for additional information about mulching.
- Ensure that a tree planting program exists to include planting younger trees in mature stands to provide for long-term tree *canopy* continuity.
- Remove and replace trees that are in poor condition as determined by an *arborist*.

Plant trees strategically around trails, picnic areas, playgrounds, and sporting fields to provide shade. The Trails Park, Summerlin

Transportation Corridors

The planting areas for trees in transportation corridors include road frontage areas along streets, roads, and highways. They are made up of the public road right-of-ways (including medians) and the adjacent property behind them. They can include residential front yards and commercial, institutional, and industrial frontages.

Frontage areas include both *street trees* and yard trees that are part of a property's landscape design and function. *Street trees* are found growing both individually and in groups.

Trees in frontage areas contribute the following benefits:

- Shade street pavement increasing its useful life
- Shade and cool homes and neighborhoods
- Create a pleasant and comfortable sidewalk environment
- Create an attractive presentation of property and buildings
- Screen the view of parking lots and utility areas from public streets
- Buffer noise and filter dust, fumes, and light
- Enhance the beauty of public thoroughfares

Species Selection

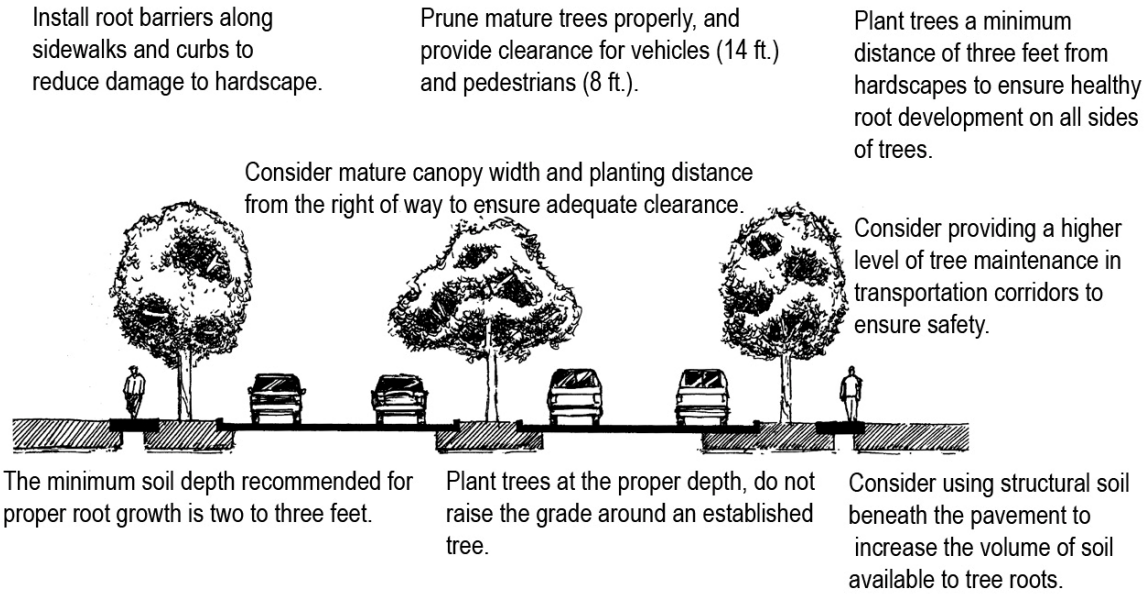
- Consider planting low *biogenic volatile organic compound (BVOC)* emitting trees.
- Plant trees only where there is adequate room, both overhead and underground, for the mature size of the tree being planted.
- Consider mature *canopy* width and planting distance from the right-of-way to ensure adequate clearance for vehicles.
- Plant a variety of species throughout a neighborhood to discourage a *monoculture*, but promote visual continuity by restricting the number of species along any individual street.
- See Appendix A – Recommended Tree Species for additional information.

Soil Considerations

- The minimum soil depth recommended for proper root growth is two to three feet. See Appendix D – Soil Volume for additional information.
- Consider using *structural soil* beneath the pavement to increase the volume of soil available to tree roots. See Appendix C – Structural Soil for additional information.
- Consider using *pervious concrete* or pavers in combination with *structural soil*. *Pervious concrete* and pavers accommodate pedestrians and vehicles, allow for increased moisture flow to tree roots, and allow for gas exchange between the roots and soil surface. See Appendix B – Pervious Concrete for additional information.
- Plant trees behind the sidewalk on adjacent private property and tree planting easements to increase growing space. *Streetscapes* and *planting medians* should be a minimum of six feet wide to allow for proper root development.

Design Considerations

- Plant trees in center medians and irrigate appropriately.
- Vary the spacing between trees to add interest and diversity to roadway plantings while ensuring that spacing between trees is adequate to support healthy mature canopies. See Appendix A – Recommended Tree Species for information about mature canopy size.
- Plant large groups of trees to provide visual relief. Scale and massing should be appropriate for speed limit of roadway.
- Prevent ownership concerns by planting trees at least three feet away from property lines.
- Plant trees a minimum distance of three feet from hardscapes to ensure healthy root development on all sides of trees.
- To ensure adequate visual site lines for motorists, consider planting trees a minimum distance of 15 feet from driveways, 35 feet from road intersections for minor streets, 50 feet for major streets, or 100 feet for arterials.
- Install *root barriers* along sidewalks and curbs to reduce damage to hardscape.
- Consider recycled *rubber sidewalks* when trees and sidewalks are in close proximity to prevent infrastructure damage by tree roots.
- Consider using *pervious concrete* or pavers, in combination with *structural soils*, for sidewalks when in close proximity to trees. See Appendix B – Pervious Concrete for additional information.
- Provide adequate irrigation in xeriscape areas. See Tree Maintenance section for additional information about irrigation.

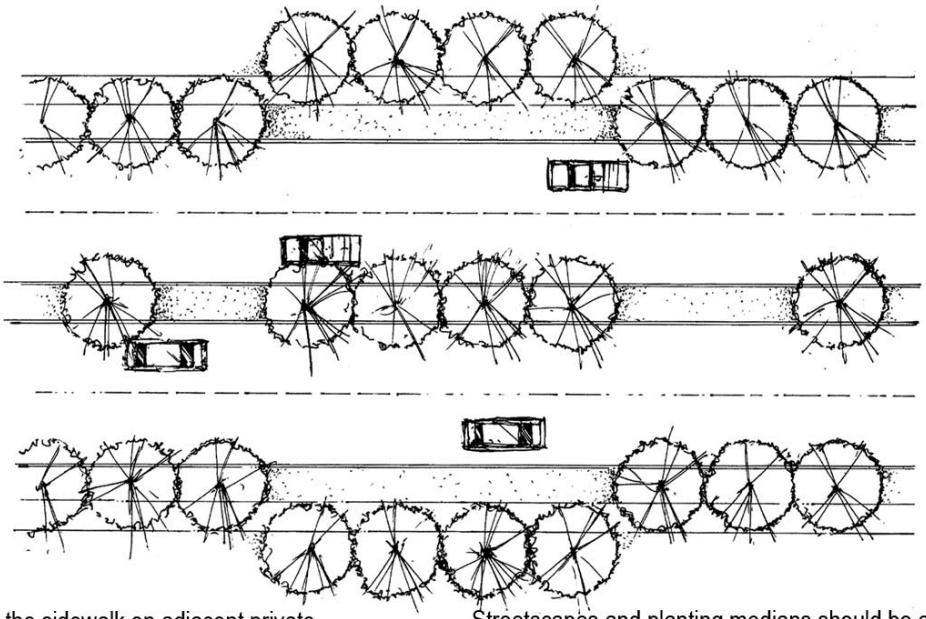


Maintenance

- Plant trees at the proper depth; do not raise the grade around an established tree. See Tree Establishment section for additional information about planting.
- Tunnel or bore during underground utility line installation when working within the *dripline* of trees. This will avoid severing or damaging roots which increases the risk of tree failure.
- Prune mature trees properly, and provide clearance for vehicles (14 feet) and pedestrians (8 feet). See Tree Maintenance section for additional information about pruning.
- Protect trees from damage during roadway construction, and remove trees that sustain root and *trunk* damage. See Tree Protection section for additional information.
- Consider providing a higher level of tree maintenance in transportation corridors to ensure safety. The level of human activity that occurs around these trees is usually high.

Plant a variety of species throughout a neighborhood to discourage a monoculture, but promote visual continuity by restricting the number of species along any individual street.

Vary the spacing between trees to add interest and diversity to roadway plantings while ensuring that spacing between trees is adequate to support healthy mature canopies.



Irrigate and plant trees in center medians.

Plant trees behind the sidewalk on adjacent private property and tree planting easements in increase growing space.

Streetscapes and planting medians should be a minimum of six feet wide to allow for proper root development.

Plant trees behind the sidewalk on adjacent private property and tree planting easements to increase growing space. Nature Discovery Park, Aliante

Alicia Ortega

Xeriscape landscaping is a good option along transportation corridors. Trees along roads have a slowing effect by giving the perception of a narrower street. Alta Boulevard, Las Vegas

Utility Corridors

Utility corridors are linear landscapes that can contain power, gas, water, sewer, or phone services. These corridors range from 20 feet to 150 feet wide, often parallel roadways, and contain aboveground and/or underground lines. Vegetation must be controlled within the corridors to allow safe maintenance and repair of the utility lines.

Trees within utility corridors contribute the following benefits:

- Create attractive tree-lined roadways and trails
- Screen utility lines from roadways and adjacent properties and soften their visual impact
- Buffer noise and filter dust, fumes, and light

Safety Requirements

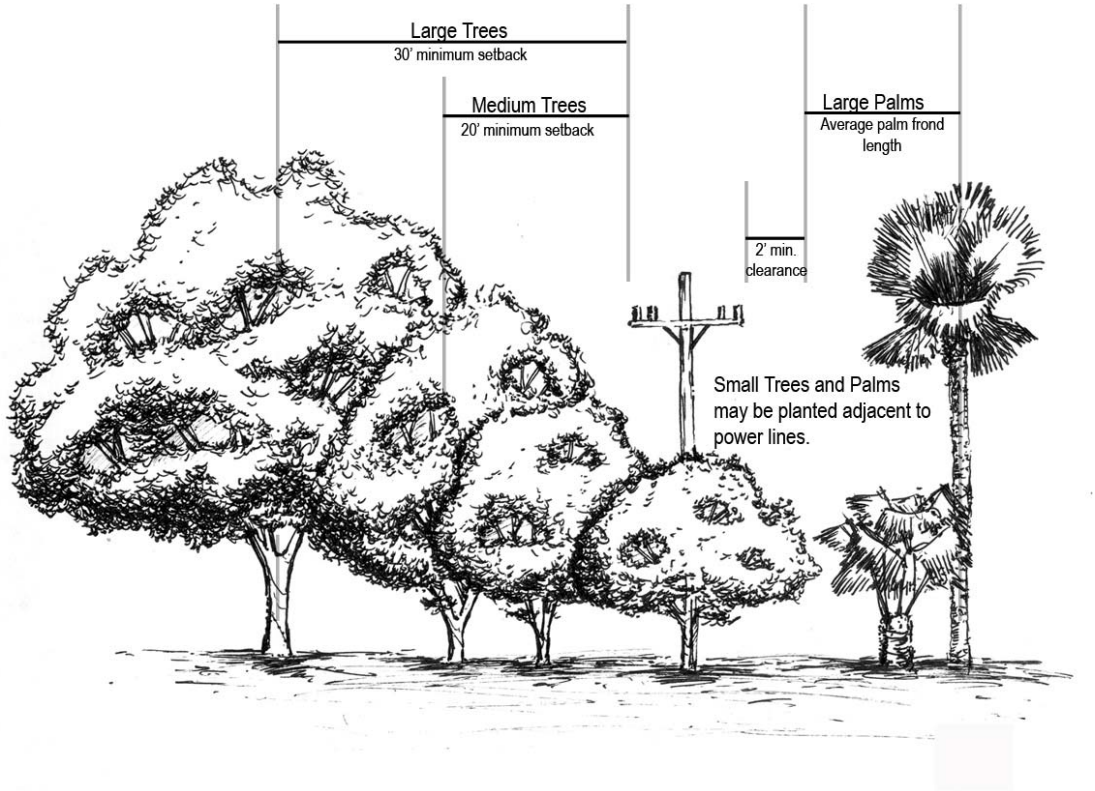
- Contact the local electric power utility before work begins, if working within 10 feet of overhead or underground high voltage powerlines. Required by law (NRS 455.200-250).
- Use only qualified line-clearance *arborists* (OSHA 29 CFR Part 1910) to work within 10 feet of distribution voltages (750 volts-50 kV) and 15-27 feet from transmission voltages (69-500 kV).
- Call Before You Dig (Nevada: 1.800.227.2600) if tunneling, trenching or digging. Call at least two days before work will begin so that underground utilities are located and marked.
- Call Before You Crane (Nevada Power Company: 702.227.2929) if overhead power lines are in close proximity to the work site and a crane or other equipment is to be used.

Species Selection and Design Considerations

- Consider planting low *biogenic volatile organic compound (BVOC)* emitting trees.
- Plant only small trees within 15 feet of overhead electrical power lines to ensure line clearance can be maintained.
- Plant medium-sized trees at least 20 feet from overhead electrical distribution lines.
- Plant large-sized trees at least 30 feet from overhead electrical distribution lines.
- Plant all trees at least 10 feet from sewer lines, 15 feet from underground electrical power distribution lines, and 20 feet from underground electrical or gas transmission lines.
- The placement of trees should not impede access for maintenance vehicles and equipment.
- Provide adequate irrigation in xeriscape areas.
- Consider establishing trails within utility corridors. Existing regional policies for utility corridors states these areas can be utilized for a variety of trails. Trees planted along these trails provide shade for users and increase their level of usage.
- See Appendix A – Recommended Tree Species for additional information.

Maintenance

- Maintain adequate clearance between trees and overhead and underground utility lines to facilitate repairs and minimize impacts to and from trees. Minimum clearance between overhead power lines and tree limbs is 15 feet. See Tree Maintenance section for additional information about pruning.
- Prune trees according to *ANSI A300 (Part 1)* and *ANSI Z133.1* standards, employing *directional pruning* to direct future growth away from conductors. Follow *natural target pruning* guidelines to remove undesirable limbs at the *branch collar*.
- Employ *crown reduction pruning* instead of tree *topping* to reduce tree size beneath utility lines.
- Remove trees in conflict with overhead electrical power lines if clearance cannot be maintained through proper pruning.
- Consider using growth regulators to reduce annual branch growth and increase the length of time between pruning cycles.
- Tunnel or bore during underground utility line installation when working within the *dripline* of trees. This will avoid severing or damaging roots, which increases the risk of tree failure.



Know where power lines and other utility lines are before planting. Plant the right tree in the right place accordingly.

Match the species mature size to the available growing space. Plant trees only where there is adequate room, both overhead and underground, for the mature size of the tree being planted. West Centennial Parkway, North Las Vegas

Consider establishing trails within utility corridors. Trees planted along these trails provide shade for users and increase their level of usage. Henderson

CHAPTER THREE

Best Management Practices for Tree Care

Chapter three draws heavily from the work of Best Management Practices for Community Trees: A Technical Guide to Tree Conservation in Athens-Clarke County, Georgia.

Tree Establishment

Tree establishment begins with a planting plan that meets the objectives of the property owner, manager, and/or local development regulations. Once the plan is approved, appropriate species can be purchased, sites prepared, and trees planted. The establishment period is usually considered to be three to five years and requires regular maintenance and watering.

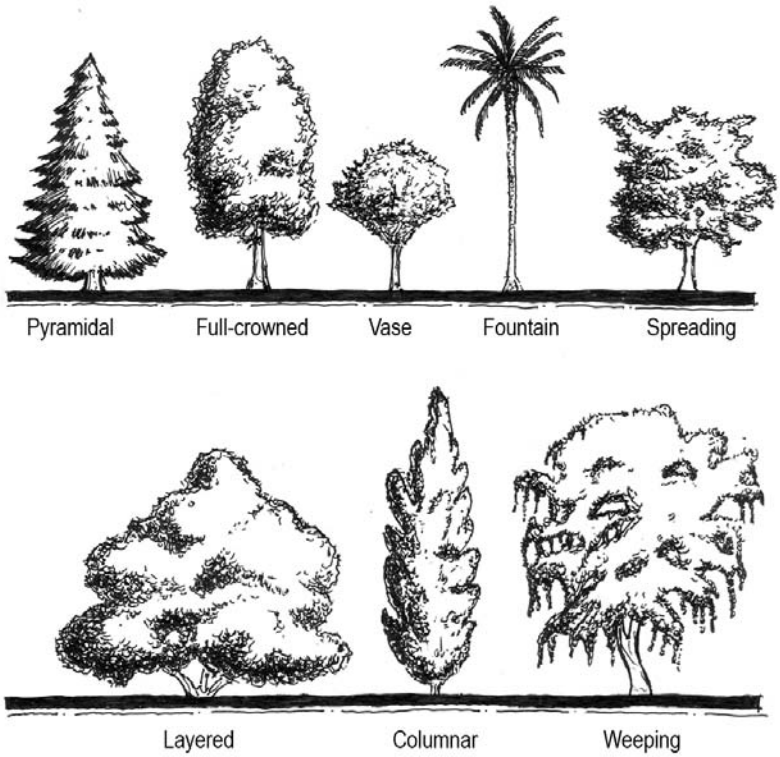
New trees should be planted regularly to replace trees that have been removed, to add to a group of trees, and to ensure that *community forests* remain fully stocked, species diverse, multi-aged, and stable.

The benefits of regular and successful tree establishment include:

- Stable tree population with a diversity of ages, sizes, and species
- Maintenance of tree c*anopy cover* for future generations
- Opportunities for community involvement in tree planting and maintenance activities
- Better survival and lower tree establishment costs

Tree Selection

- Plant the right tree, in the right place.
- Match tree growth requirements with soil and environmental site conditions. Select trees that match or exceed the minimum plant zone hardiness for the area.
- Select a tree of appropriate size and shape at maturity for the site.



Trees grow in a variety of shapes and sizes.

- Select good quality planting stock:
  - Trees with a good quality root system
  - A straight *trunk* without wounds
  - A single, central leader (no "forked" stems)
  - A full, well-balanced *crown*

- For species that are typically multi-stemmed, such as mesquite or palo verde, choose stock that does not contain *included bark* between the stems. For additional information consult the *American Standard for Nursery Stock, ANSI Z60.1.*

Russ Thompson

Avoid trees with *included bark* and *co-dominant* stems.
Private residence, Las Vegas

- Inspect the roots before purchasing container grown trees by removing the plant from the container. Look for problems such as *girdling roots*, inadequate moisture, too much moisture, broken roots, and an inadequate amount of roots.

- Protect trees from wind damage during transport in an open bed vehicle by covering with a tarp or landscape fabric.

Site Selection

- Plant trees where they have room to grow to maturity, both above and below ground, without their health or form being compromised by conflicts with infrastructure.
- Provide trees with adequate soil volume for healthy tree growth. See Appendix D – Soil Volume for additional information.
- Ideally, plant trees at least 10 feet away from underground utility lines and utility boxes.
- Plant only low-growing tree species within 15 feet of overhead utility right-of-ways. See Appendix A – Recommended Tree Species for additional information.
- Consider long-term redevelopment of the site and the potential to maintain the *canopy* as land-use changes.
- Ensure that trees stored on-site prior to planting receive adequate irrigation. See Tree Maintenance section for additional information about irrigation.

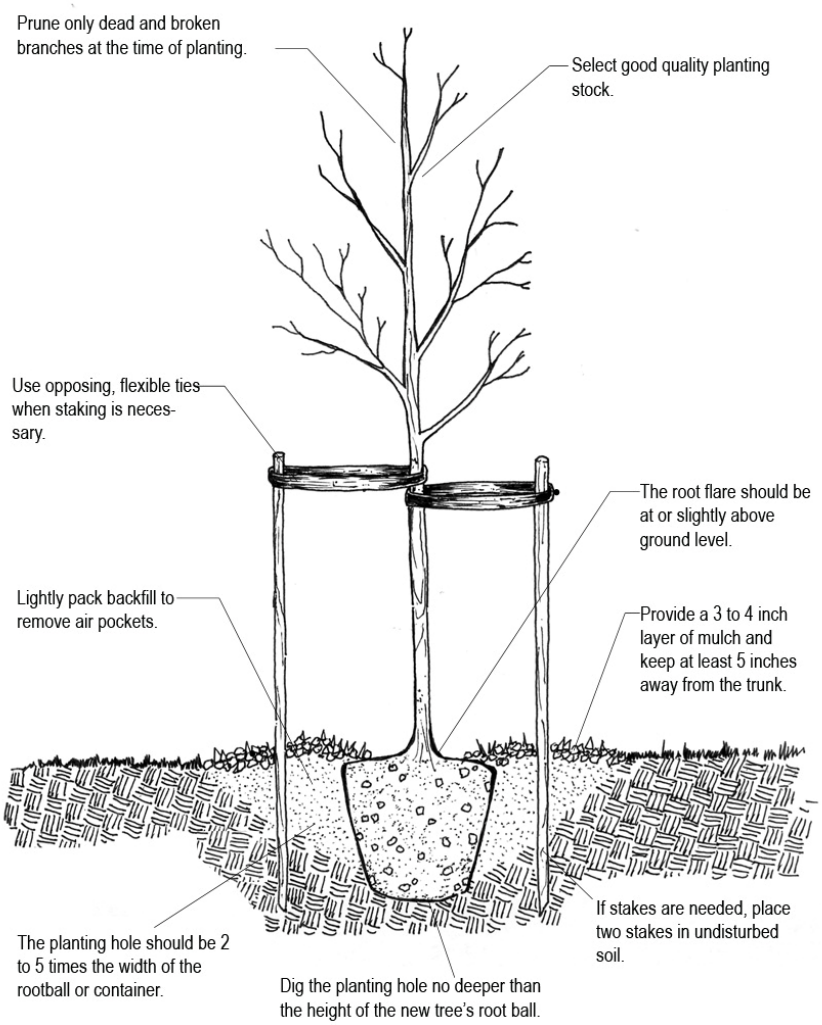
Site Preparation

- Call Before You Dig (Nevada: 1.800.227.2600). Contractors and homeowners are required by law to call at least two working days before digging so that underground utilities are located and marked.
- Have the soil tested for existing conditions such as texture, organic matter, pH, compaction, contaminants, etc. Amend the soil as needed. See Soil Health Maintenance section for additional information.
- Dig a planting hole that is two to five times the width of the root ball or container.
- Dig the planting hole no deeper than the height of the new tree's root ball. Holes that are too deep should be backfilled and compacted to a depth a few inches shallower than the height of the root ball to allow for settling. A major cause of death for newly planted trees is planting too deep.
- Fill the hole with water. If it drains within two hours, proceed. If not, dig a *chimney tunnel* at the base of the hole to break through to a more porous level. An alternative to digging a *chimney tunnel* is to plant above grade after bringing in additional soil.

Tree Planting

- The ideal time to plant trees in southern Nevada is during the dormant season, late fall through early spring.
- Move the tree by handling the root ball or container only. Don't use the tree *trunk* as a "handle" to move trees which can cause the root ball to break away from the *trunk*.
- Remove soil from the top of the root ball or container until the root flare is located. The root flare is usually located a few inches beneath the root *graft*, if there is one present.

- Inspect the root ball for circling roots and separate and spread them outward. If roots are densely matted and cannot be teased apart, they should be cut in two places to stop the circling.
- Place the tree so the root flare is at or slightly above ground level, never below, to allow for settling.
- Remove all packing materials such as shipping tubes, stakes, tags, wires, string, twine, straps, burlap, wire baskets, and wood boxes.
- Mix reserved soil thoroughly with organic material at a rate of two parts native soil to one part amendment. You may decide not to include organic material when planting desert trees which ultimately do better when planted in soil that has not been amended.
- Apply organic matter to the depth of three or four inches over the entire site to be landscaped. See Tree Maintenance section for additional information about mulching.



Proper tree planting

- Backfill the hole with amended soil and/or native soil, packing soil lightly as you fill to remove air pockets. Watering is also an effective way to remove air pockets. Bring soil level even with the top of the root ball. Cover the top of the root ball with mulch only.

- At the time of planting, install low-flow irrigation components so that water is applied over the majority of the estimated mature tree *critical root zone (CRZ)*. See Tree Protection section for additional information about the *CRZ*.

- Install emitters directly over the root ball to provide sufficient water during the establishment period. See Tree Maintenance section for additional information about irrigation.

- Stake only trees unable to stand upright on their own. If staking is necessary, reevaluate after six months and remove the stakes as soon as the tree can support itself. Stakes should be removed within one year of planting.

- If stakes are needed, place two stakes in undisturbed soil at right angles to the prevailing wind. Never use wire in a hose to attach the stake to the tree. Use flexible materials such as nylon webbing. Allow the *trunk* to flex in the wind to allow the tree to build taper for strength.

- Tree wraps are not recommended. Any material applied directly to bark might trap moisture, which may lead to stem diseases, decay and harbor insects such as woodborers and wasps.

- Prune only dead or broken branches at the time of planting; and prune dead, broken, crossing, or rubbing branches annually thereafter. See Tree Maintenance section for additional information about pruning.

New Tree Maintenance

- Mulch newly planted trees to a depth of three or four inches and in a five-foot radius around the tree. Use composted organic matter such as wood chips, leaves, and twigs.

- Keep mulch at least five inches from the base of the tree *trunk*. This will decrease the possibility of damage by rodents or insects sheltered by the mulch, and the possibility of crown rot caused by the constant presence of moisture on the *trunk*.

- Establish a *CRZ* around new trees during construction activities.

- Inspect newly planted trees regularly to evaluate their condition and maintenance needs.

- Irrigate newly planted trees frequently, one to three times per week, during the initial establishment period (approximately 30-60 days). Gradually decrease frequency and increase depth (by increasing time of each irrigation event) periodically until the regular watering schedule is reached.

Soil Health Maintenance

Trees thrive in soil similar to that in their natural environment.

The basic components of soil include mineral matter, organic matter, soil organisms, and pore spaces that hold water and oxygen. Both the texture of the soil (relative components of sand, silt, and clay) and the structure of the soil (arrangement of soil particles) are important factors in determining how much water and oxygen a soil can hold.

Soil fertility is also important and can be evaluated using standard tests to measure the amount of nutrients, such as nitrogen, phosphorous, potassium, calcium, iron, magnesium, zinc, manganese, sulfur, and other nutrients in the soil. The availability of these elements is affected by soil pH and organic matter content. Soil tests can determine the soil pH (acidity/alkalinity) and the amount of organic matter present by weight. Contact Cooperative Extension (Clark County: 702.222.3130) for a list of laboratories that can provide soil tests.

Maintaining good soil health and adequate soil volume provides the following benefits:

- Improved tree survival, growth, and longevity
- Maintenance of structural integrity of the root system and reduction in the probability of whole tree failure
- Allows for root development without intrusion of roots into sewer lines
- Reduced soil erosion and improved water quality

Soil Surface Area and Volume

A tree's requirement for growing space and soil rooting volume increases as tree age and size increases. Trees should be provided with enough growing space for their future mature size. If adequate soil volumes are not available throughout a tree's life, then much more intensive management is required or the tree's size, condition, and useful life span will be limited.

The minimum soil depth recommended for proper root growth is two to three feet. Ideally, enough exposed soil surface area should be provided to allow the roots to grow at least to the *dripline* of a mature tree. See Appendix D – Soil Volume for additional information.

- Obtain a soil test to provide baseline information on nutrient availability, organic matter content, and pH. Ideally, *prescription fertilization* should be utilized.
- Know the pH requirements of your trees. Obtain the appropriate pH by amending the soil with elemental sulfur and composted organic mulch. Southern Nevada soils are typically alkaline and lowering pH below 8.0 is a good goal.
- Mulch around trees to a depth of three or four inches to increase soil nutrient levels, organic matter content, improve soil structure, and conserve soil moisture. Keep mulch at least five inches from the base of the tree trunk. This will decrease the possibility of damage by rodents or insects sheltered by the mulch, and the possibility of crown rot caused by the constant presence of moisture on the trunk.
- Avoid soil compaction within the *CRZ*. Compaction decreases the porosity of the soil resulting in reduced amount of available water and oxygen and can injure or kill tree roots. See Tree Protection section for additional information about the *CRZ*.

- Do not allow, under any circumstances, the parking of vehicles or storage of heavy equipment and/or construction materials within the *CRZ*.
- Use *vertical mulching* techniques to improve soil aeration.
- Consider the use of *structural soil* to improve root penetration while achieving soil compaction standards. See Appendix C – Structural Soil for additional information.

Tree Maintenance

Tree maintenance is routine care given to a tree throughout its life to preserve or improve its health, function, and safety. The amount of maintenance a tree requires depends on the species, the tree's location in the landscape, its age, and the care (or abuse) it's been given. Tree maintenance begins with regular inspections to determine if a tree needs pruning, mulching, fertilizing, irrigating, or pest management.

Pruning

Pruning is the deliberate removal of tree branches and limbs to achieve a specific objective. Regular inspections to determine a tree's pruning needs should be a part of every tree maintenance program.

The *American National Standards Institute (ANSI)* and the *International Society of Arboriculture (ISA)* publish tree pruning and safety standards, known as *ANSI A300 (Part 1) Pruning Standard*. These standard practices should be followed whenever possible.

The benefits of regular and correct tree pruning include:

- Proper tree form, improved health and structural integrity
- Removal of decaying and diseased wood
- Decrease in overall risk of limb failure and liability
- Reduced maintenance needs in the future

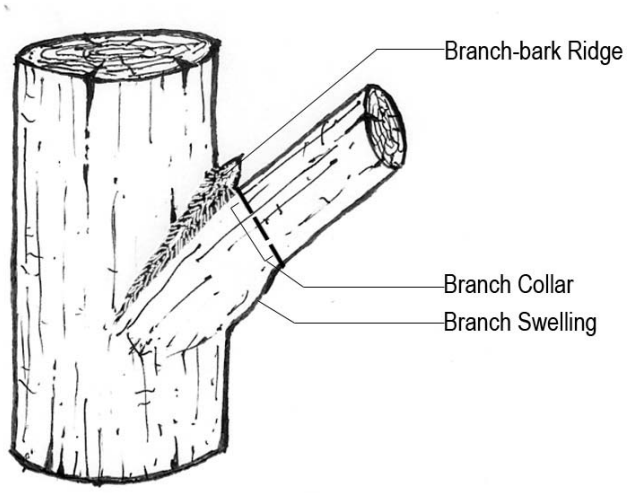
Safety

- Personal protective equipment (PPE) must always be worn while pruning, including safety glasses, helmet, ear protection, gloves, etc. Chainsaw chaps are required if using a chainsaw on the ground.
- Trees must be inspected before being climbed to determine the amount and extent of hazards. The tree owner should be notified of potentially hazardous or harmful conditions.

General

- Hire only licensed tree care businesses, and experienced professionals to prune and maintain trees. *Arborists* and tree workers certified by the *International Society of Arboriculture* are required to pass a written test of basic arboricultural knowledge and to attend continuing education courses to maintain their certification.
- Do not allow trees to be *topped*. This is an unacceptable practice and greatly decreases tree health, safety, longevity, aesthetics and other benefits provided.
- Do not allow the use of climbing spikes, spurs, or gaffs, except during an emergency rescue or tree removal, as they injure trees.
- Prune when trees are dormant, in Southern Nevada this is usually during the months of December through February. Pruning should not be done when the tree's buds are beginning to swell in the spring, nor in the fall just prior to leaf drop.

Figure 1.
Where to make a proper pruning cut



- No more than one-fourth of the foliage of a mature tree or any individual branch should be removed in any one growing season. Healthy, vigorous, young trees can tolerate up to one-third of the foliage removed in any one growing season.
- Use the right tool for the size of the job. Hand tools such as loppers and hand saws will make cleaner cuts and do less damage than a chain saw. Only use a chain saw for larger branches.
- A proper pruning cut begins just outside the *branch bark ridge*, avoiding injury to the *branch collar*. If no collar is visible, the angle of the cut should approximate the angle formed by the *branch bark ridge* and the *trunk*. Flush cuts make larger wounds, increase decay, and should be avoided. See Figure 1.
- Prune trees when young to develop good branch structure, strength, and form.
- Remove competing leaders on trees with *co-dominant* stems.
- Make pruning cuts using the *three-cut method* for heavy branches (larger than three inches) to avoid damaging remaining bark. Avoid stub cuts, flush cuts, and wounds to remaining limbs and *trunk*. See Figure 2.
- Always prune trees back to the *parent branch* or a *lateral branch* that is at least one-third the diameter of the branch being pruned.
- Keep pruning equipment sharp, clean, and in good operating condition.
- Clean pruning equipment with bleach or a similar product after pruning limbs that show evidence of disease. Diseases such as fusarium and sooty canker can be spread to palm trees and shade trees, respectively, if sterilized tools are not used.

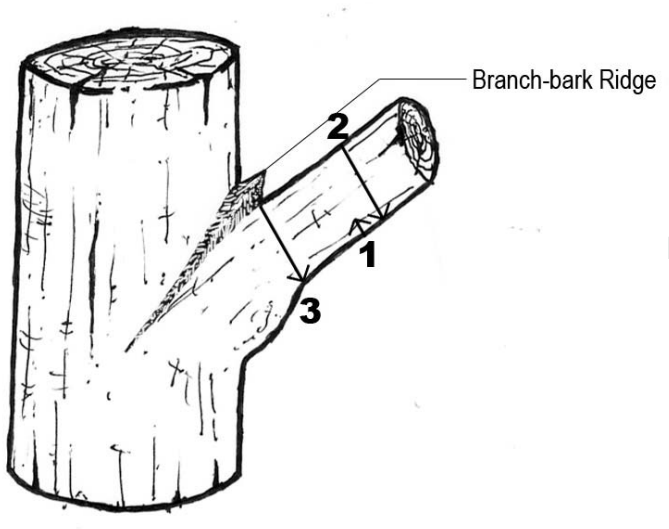


Figure 2.
Three-cut method

- Wound dressings or pruning sealers are not recommended because they may harm the tree by trapping moisture and disease spores.
- Encourage *canopy* growth, but prune trees regularly to maintain vehicular, pedestrian, and sight clearance, and to remove dead wood, crossing, and broken branches.

Utility Line Clearance

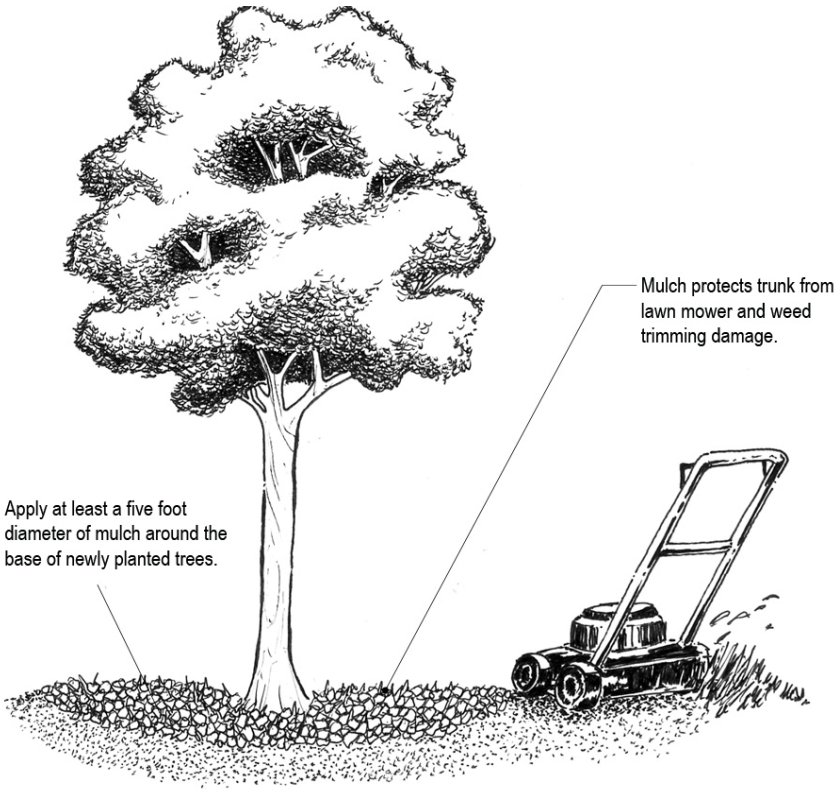
- Use only qualified line-clearance arborists to prune or remove trees located beneath or near overhead utility lines. To have a tree pruned or removed that is growing beneath or near overhead utility lines, contact your utility service provider.
- Talk to your utility provider about their needs for line clearance and their use of pruning techniques designed to maintain that clearance.
- Ensure that *directional pruning*, *natural target pruning*, and *crown reduction pruning* techniques are employed when trees are being pruned for line clearance. Do not allow *topping*.

Mulching

Mulching is the application of organic material on top of the ground. It is applied over a tree's root system to improve soil moisture and fertility, improve soil aeration, moderate soil temperature, suppress competition from weeds and lawn, and to enhance root and tree growth. An area of mulch around the base of trees eliminates the need for mowing and weed trimming, which can damage the tree *trunk*.

- Apply at least a five foot diameter of mulch around the base of newly planted trees, to a depth of three or four inches. For established trees, mulch to the *dripline*, or as far out as practical.

- Keep mulch at least five inches from the base of the tree *trunk*. This will decrease the possibility of damage by rodents or insects sheltered by the mulch, and the possibility of crown rot caused by the constant presence of moisture on the *trunk*.
- Replenish mulch annually. Organic mulch, such as composted wood chips, provides greater benefits when compared to inorganic mulch such as gravel or rock.
- Hand pull or use a contact herbicide to kill weeds growing within mulched areas under trees. Avoid using weed trimmers around the base of trees. They can severely injure the *trunk*, often resulting in early death.



An area of mulch around the base of trees eliminates the need for mowing and weed trimming, which can damage the *trunk*.

Fertilization

Fertilization is the application of nutrients to the soil or leaves to enhance growth or maintain vitality. It should only be done for a specific purpose or to correct a specific deficiency discovered through soil testing or foliar analysis.

The *American National Standards Institute (ANSI)* and the *International Society of Arboriculture* have standards for tree fertilization that have been published as *ANSI Standard A300 (Part 2) Fertilization Standard*. These standard practices should be followed whenever possible. Cooperative Extension (Clark County: 702.222.3130) can also provide fertilization recommendations.

The benefits of fertilization include:

- Healthier, more extensive root systems
- Increased growth and larger trees at an earlier age
- Healthier trees in better condition for defense against pests

- Apply fertilizer based on results from a soil test to address known deficiencies. This is called *prescription fertilization*.
- In the absence of a recent soil test, use an NPK (nitrogen-phosphorus-potassium) fertilizer ratio of 3:1:1 or 3:1:2.
- Do not apply fertilizer to newly planted, drought stressed, or severely wounded or injured trees.
- Apply fertilizer when the roots are actively growing; late winter, spring, and early summer are the best times to fertilize.
- Use slow release organic fertilizers with a *salt index* of less than 100. Southern Nevada soils naturally have a high concentration of salt, which can damage or kill plants.
- Apply slow release fertilizers to trees at a rate between 2 and 4 pounds of nitrogen per 1000 ft^2 of root area per year. It is best to split this into two or three applications throughout the growing season.
- Apply fertilizer to the *CRZ* of trees, beginning two feet away from the *trunk* and extending to the *dripline*, but only once to overlapping root zones.
- Make sub-surface applications of fertilizer where turf or groundcover exists, or where runoff is likely. These applications should be 4-12 inches deep, in holes that are 2 to 4 inches in diameter and spaced 12 to 36 inches apart. Fertilizer should not be closer than 2 inches to the surface.
- Do not inject fertilizer into the *trunk* for routine fertilization as this harms the tree.
- Foliar application of minerals, such as chelated iron sprays, produce rapid, temporary treatment for deficiencies, such as iron chlorosis, but are not recommended for long-term use.

N-P-K	Pounds of Fertilizer to Apply Per 1000 Sq. Ft. to Achieve a Rate of		
Fertilizer Formulation	2.0 lbs of N	3.0 lbs of N	4.0 lbs of N
5-X-X	40.0	60.0	80.0
10-X-X	20.0	30.0	40.0
15-X-X	13.3	20.0	26.7
20-X-X	10.0	15.0	20.0
30-X-X	6.7	10.0	13.3

Table 2. Amount of fertilizer to apply to achieve recommended nitrogen fertilization rates

Irrigation

Irrigation is the application of water to the root system of a tree. Water is essential to tree growth, the absorption of elements and nutrients, and the production of food energy. Irrigation may be done using a hose, sprinkler, bucket, large capacity water tank, or installed irrigation system.

Proper irrigation provides benefits such as:

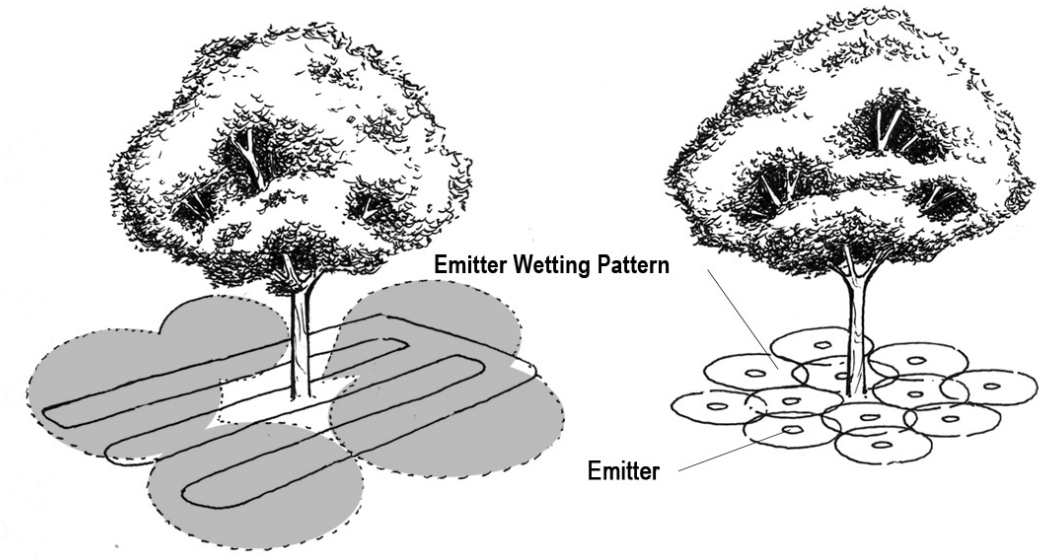
- Better tree growth with fewer periods of stress
- Less susceptibility to insect and disease infestation
- Better tree survival, less replanting, more economical tree establishment costs
- Requires visits to the tree which can also serve as a time for regular tree inspections

- Plant trees so the root flare is at or slightly above ground level to avoid creating a place where excessive water accumulates. See Tree Establishment section for additional information about planting.
- Place trees on their own irrigation valve and line, independent of shrubs, groundcovers, and turf grass.
- Irrigate the soil under the tree canopy and just beyond to encourage root growth.
- Water trees before they show signs of water stress, such as wilting or leaf scorch.
- Apply water slowly to avoid runoff.
- Determine the spacing and flow rate of drip emitters by soil type:
  - Clay soil and hard soils require emitters to be spaced relatively far apart with a low flow rate.
  - Loam soil requires emitters to be spaced moderately far apart with a medium flow rate.
  - Sandy soil requires emitters to be spaced closer together with a high rate flow.
- Water less often with greater amounts of water rather than more often with smaller amounts of water.

- Water well-established trees by starting with the following schedule and adjust, as needed, to allow for soil type and seasonal conditions:
  - Non-desert trees

    Winter: Deep watering once or twice a month
    Spring/Fall: Deep watering two to four times a month
    Summer: Deep water once or twice a week
  - Desert trees

    All seasons: Water deeply and less frequently, about half as often
- After watering, check how deeply water has penetrated the soil after watering. A metal rod or root feeder shaft will easily penetrate moist soil, while dry soil is difficult or impossible to penetrate with a probe. Apply enough water to penetrate the soil to a depth of 18 to 24 inches.
- Allow the soil to dry out completely between irrigation cycles. Saturated soil suffocates roots by eliminating oxygen needed for normal respiration.
- During summer months, minimize evaporation by watering during the cooler hours of early morning or late evening.
- In the winter, eliminate potential for irrigation systems to freeze by not watering during the night or early morning.
- Inspect irrigation systems annually and add additional emitters as trees grow.
- Mulch trees to conserve water. See Tree Maintenance section for additional information about mulching.



Two drip-options, Left: in-line drip emitter layout showing tubing placement.
Right: conventional emitter layout showing emitter placement.

Pest Management

Pest management is the control of weeds, insects, fungi, bacteria, or other tree pests through a variety of techniques and at a level that meets management objectives.

The best approach to pest management is *integrated pest management (IPM)* that utilizes prevention, biological and cultural controls, and when warranted and absolutely necessary, chemical controls.

The benefits of timely pest management include:

- Increase in knowledge of impact and life cycle of tree pests
- Reduction in the number of trees affected
- Increased tree health with timely pest identification and management

- Hire only experienced and knowledgeable professionals to apply pesticides. Private and commercial pesticide applicators are required to be certified to apply restricted use pesticides. Contact the Nevada Department of Agriculture (775.688.1180) for additional information.
- Consider all potential *abiotic* causes of tree disorders before investigating possible *biotic* causes. Problems are often misdiagnosed as *biotic* when they are actually *abiotic* in nature.
- Learn the habits and life cycle of the pests affecting your trees, and know when to apply pesticides for the greatest effect.
- Matching tree species to site conditions at planting will reduce stress and predisposition of trees to pest attacks.
- Protect tree roots, *trunk*, and limbs from wounds. Wounds are entry points for insects and diseases, including those which cause decay.
- Soil active herbicides or “weed-and-feed” lawn formulations should not be applied over the root systems of trees.
- Mulching around the base of trees may create healthier trees that are more pest resistant. Healthy trees are the best defense against future problems. See Tree Maintenance section for additional information about mulching.

Tree Protection

Tree protection preserves tree health by avoiding damage to tree roots, *trunk*, or *crown*.

Passive tree protection involves avoidance of any disturbance or harmful activity near a tree. Active tree protection is required prior to the onset of construction activities by planning for tree preservation. It occurs during events involving land development, building construction and maintenance, infrastructure installation and maintenance, and other landscape changes that could have a major impact on trees.

Some benefits of protecting trees in new and existing developments include:

- Reduced long-term tree maintenance and replacement costs
- Larger trees and greater *canopy cover* providing immediate benefits
- Positive feedback from neighbors and good public relations
- Healthier trees and environment

The Critical Root Zone

If a tree protection plan is to be successful, one must fully understand the concept of the *critical root zone (CRZ)*. One of the most critical steps in planning for trees and cost effective ways of managing trees is to maintain adequate growing space for each tree's roots, *trunk*, and *crown* throughout the tree's life. The growing space a tree requires as it gets older and larger increases proportionately.

There is a minimum area, above (for the *trunk* and *crown*) and below ground (for soil health and the root system), that is required to protect trees and preserve tree health. This area has been identified as the *CRZ*. Traditionally the *CRZ* was defined as the soil area beneath a tree's *dripline*, or the greatest extent of branches. However, for many trees such as those with a narrow *canopy*, the *dripline* defines an area that is too small for proper protection. Therefore, it is best to define the *CRZ* as the circular area above and below ground with a radius equivalent to the greater of 6 feet or 1.5 feet for every inch in *trunk* diameter at 4.5 feet above the ground (*diameter at breast height* or *DBH*). For example, a tree with a *DBH* of 20 inches has a *CRZ* of 30 feet (20 inches x 1.5) around the tree. While the radius of the *CRZ* is 30 feet, the diameter of the entire *CRZ* is 60 feet. See Figure 3.

For all phases of Tree Protection:

- Employ the services of a professional *arborist*, *urban forester*, or other tree care professional to assist in tree protection planning, implementation, monitoring, and follow-up maintenance.
- Deeply water trees; mature trees are not typically "tapped" into the water table. See Tree Maintenance section for additional information about irrigation.
- Confine construction offices, vehicular parking, worker break sites, and material storage to places outside of the *CRZ*.

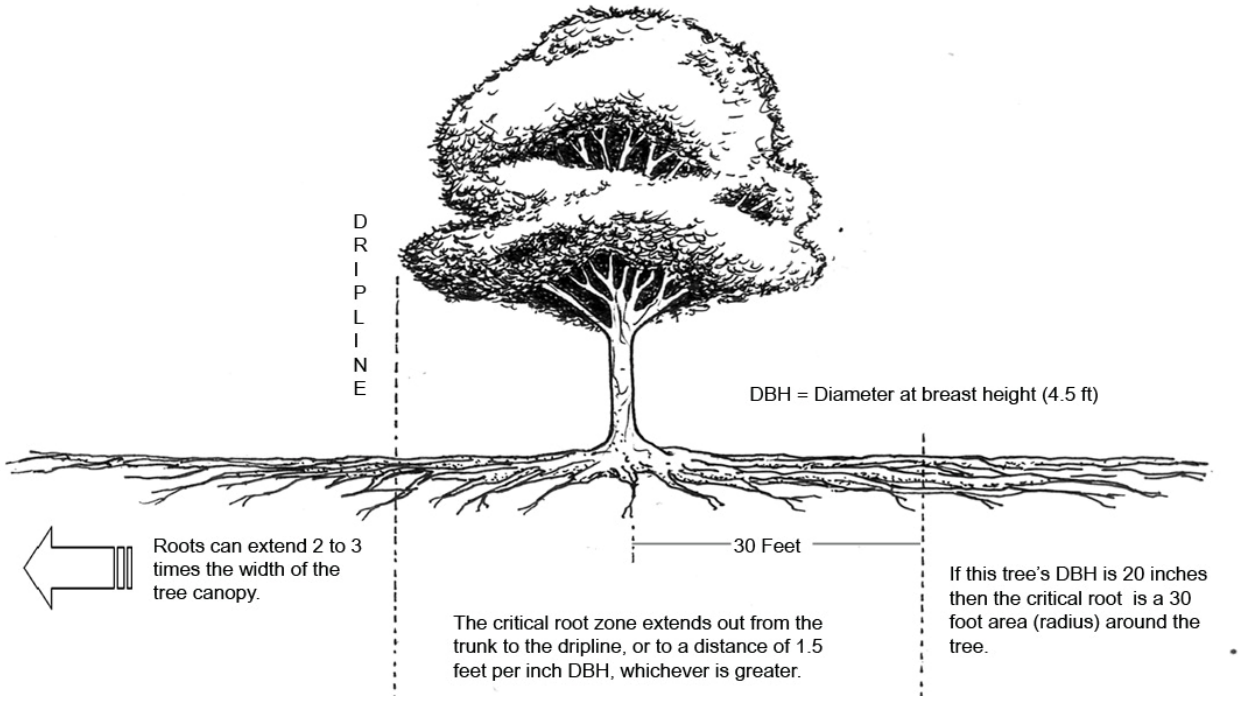


Figure 3. The Critical Root Zone

- Avoid damage to all parts of trees, especially tree roots. Protect trees located on adjacent property whose roots grow into or over property lines.
- Establish and monitor contractor's compliance with tree protection standards and check tree health regularly during construction. Remove badly damaged trees or trees in decline, and have the contractor replace all such trees with comparable species.
- Keep the *CRZ* mulched at all times and increase the *CRZ* as the tree gets older and grows larger.
- Alter the route of underground and overhead utility lines and irrigation systems that would require trenching or severe pruning of protected trees. If the route cannot be altered, tunnel or bore at least 18 inches beneath the surface.

Pre-construction Planning

- Plan and budget for tree conservation and protection as part of the initial development process.
- Begin tree protection maintenance at least one growing season prior to the beginning of construction activities. Pre-construction maintenance involves mulching the *CRZ*, fertilizing, providing supplemental irrigation as necessary, and pruning to remove dead, structurally weak, and low hanging branches.
- Evaluate soil health and site history and incorporate into tree protection measures.

- Evaluate existing trees and select trees that will be conserved and protected based upon their location, species quality, health, and benefits. Protect all trees that are worth saving; do not conserve poor quality trees. Make recommendations to save as many existing, worthy trees as possible. See Risk Management section for additional information.
- Remove trees within 30 feet of the proposed building or structure. Damage to trees is likely to happen within this area.
- Remove trees that cannot be protected, those that exhibit signs of stress, and those that have more than one-third of the *trunk* circumference wounded prior to construction activities.
- Save trees that are in groupings to facilitate their protection, maintenance, and long-term viability.
- Establish substantial penalties for damaging trees and noncompliance with tree protection requirements.

Implementation and Monitoring

- Educate all workers on site about tree protection techniques and requirements.
- Identify and mark each tree's *CRZ* prior to construction. Use barriers or sturdy fencing around individual trees or groups of trees, and clearly identify the perimeter of the *CRZ* with high visibility signs.
- Protect high value trees not only with barriers, but also with stem, branch, and root padding or wraps.
- Establish one entrance and exit to the site.
- Where tree roots must be cut, make only sharp, small clean cuts to promote root regeneration. Do not allow large roots to be cut. Instead, insist on tunneling or rerouting the trench.
- Do not allow soil contamination from concrete wash-out, oil, gasoline, paint, paint thinner, or other chemicals such as cleaning products. Locate disposal areas off-site if possible.
- Do not allow *crown* contamination from airborne particles such as sanding, plaster repair, etc.
- Do not allow wires, cables, lights, conduit, mailboxes, or other objects to be attached to trees.
- Do not allow walkways and driveways to be installed within the *CRZ* of valuable, large, and mature trees.
- Assess and enforce penalties for damaging trees and noncompliance with tree protection requirements.

Follow-up Maintenance

- Complete post-construction tree maintenance including pruning, mulching, irrigating, and soil aeration where necessary.
- Fertilize lightly with nitrogen after one year, and then make annual light nitrogen applications for the next three to five years. See Soil Health Maintenance section for additional information about fertilization.
- Inspect trees annually for three to five years after construction to look for changes in condition and signs of insects or disease, and to determine maintenance needs including necessary removals.

- Continue to protect not only the large, established trees on the site but also those newly planted in the landscape.
- Replace trees that were removed prior to or during construction activities.

Ongoing Protection

- Maintain an “invisible” passive *CRZ* around all trees throughout their lives.
- Do not allow damage to tree *trunk* and bark from mowers and weed trimmers, by keeping grass away from the base of trees.

Risk Management

The overall goal of risk management program is to maintain public safety through tree removal and replacement, while maintaining *community forest* health and preserving *canopy cover*.

Trees may need to be removed because they may be growing in the wrong location, without adequate growing space, or are in conflict with hardscape (driveways, walkways, etc.) or other infrastructure (buildings, roadways, overhead utility lines). They may be declining, dead, or hazardous, and may require removal to protect the safety of the owner or the public in general.

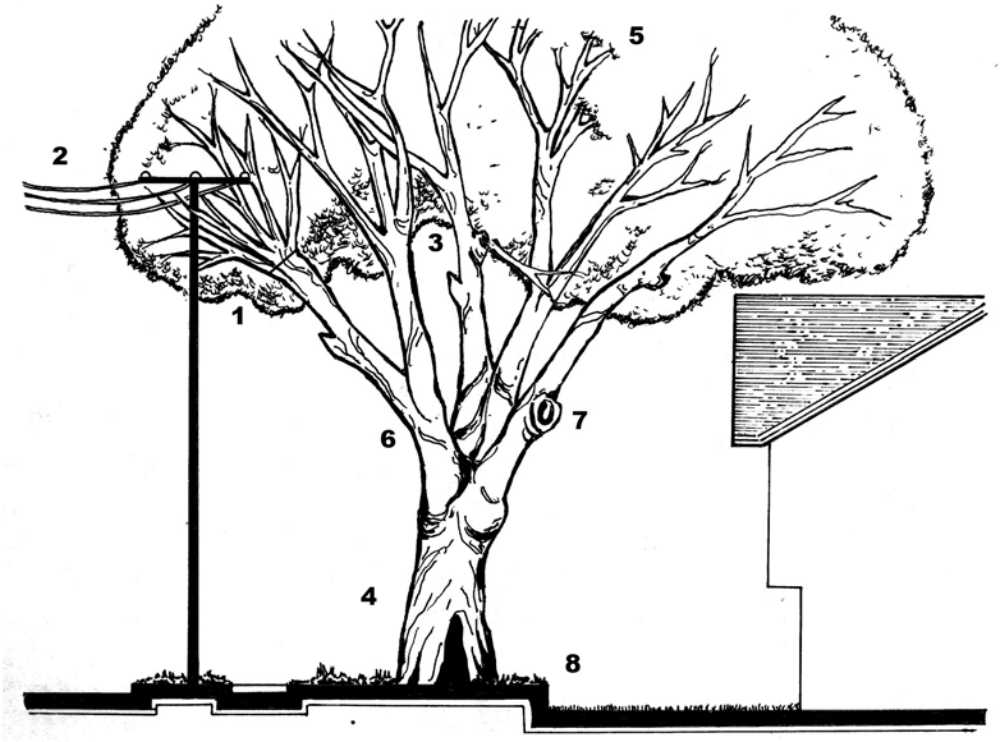
Whatever the reason for removal, the site should be evaluated to determine if another tree can be planted in the same or a nearby location to maintain *canopy cover* in the area.

The benefits of timely tree removal and replacement include:

- Reduced risk of failure and liability with the prudent systematic removal of trees
- Reduced risk of pest infestations and damage to other trees
- Additional space for new, vigorously growing trees
- Dynamic, diverse *community forest*
- Maintenance of tree stocking levels

- Positively identify ownership before authorizing tree removal.
- Have an experienced *arborist* evaluate tree health and risk for failure before removing old, large, landmark, or historic trees, or trees damaged in a storm.
- Hire only experienced professionals to remove trees.
- Reduce the number and frequency of necessary tree removals through proper tree selection, placement, protection, and maintenance.
- Hire an experienced professional to conduct a tree risk assessment. This should include the assessment of the probability of failure, size of part that may fail, and the targets that may be affected should the tree fail. Rate trees and treat the highest priority trees first. Keep detailed records of assessments and treatment decisions.
- Consider alternatives to removal such as pruning, cabling and bracing, fencing-off, or removing targets such as park benches.
- Remove trees in irreversible health decline and poor condition, and replace where appropriate.
- Remove trees creating a hazardous situation that cannot be remedied with pruning, cabling and bracing, fencing-off, or removal of the target.
- Replace trees with characteristics in conflict with the site, such as an oak with large acorns planted in a parking lot.
- Replace trees with inadequate growing space, unattractive form, or messy, hazardous, or noxious flowers or fruit.
- Replace trees with large *canopy* trees if space permits. Request the local power company to remove trees, if required, located near or beneath overhead utility lines. Do not attempt to remove these trees yourself.

- Consider restricting public access or moving valuable structures to preserve, as long as possible, landmark or historic trees with an increased risk of partial or whole tree failure.
- Establish authority under ordinance to deal with privately owned trees that pose a risk to public health and safety.



Defects or signs of possible defects in urban trees:

1. Re-growth from *topping*, line clearance, or other pruning
2. Electrical line adjacent to tree
3. Broken or partially attached branch
4. Open cavity in *trunk* or branch
5. Dead or dying branches
6. Branches arising from a single point on the *trunk*
7. Decay and rot present in old wounds
8. Recent change in grade or soil level, or other construction

APPENDICES

Appendix A – Recommended Small Trees

Common Name	Botanical Name	Height	Width	Tree Type			Growth Rate			Water Use			Litter			Spines or Thorns	BVOC			Parking Lots
				Deciduous	Evergreen	Semi-evergreen	Slow	Moderate	Fast	Low	Medium	High	Leaves	Flowers	Seeds/cones	Yes or No	Low	Medium	High	Yes or No
Acacia, Cat's Claw	Acacia greggii	15	20	x			*	*		x					*	Y	L			N
Acacia, Mulga	Acacia aneura	18	18		x		*	*		x						N		M		Y
Acacia, Sweet	Acacia farnesiana (=A. smallii)	25	25		x		*	*		x			*		*	Y		M		N
Acacia, Twisted	Acacia schaffneri	20	20	x			*			x			*	*		Y		M		N
Acacia, White Thorn	Acacia constricta	10	15	x			*			x					*	Y		M		N
Ash, Littleleaf	Fraxinus greggii	12-15	10-15			x	*				x					N	L			Y
ChasteTree(Vitex)	Vitex agnus-castus	25	25	x			*				x		*		*	N	NA			Y
Desert Willow	Chilopsis linearis	25	30	x				*			x			*	*	N		M		Y
Elderberry, Mexican	Sambucus nigra ssp. cerulea	10-20	25			x		*		x	x					N	L			Y
Golden Ball Lead Tree	Leucaena retusa	20-25	15-25	x				*		x	x		*	*	*	N		M		Y
Jujube, (Chinese Date)	Ziziphus jujuba	15-20	15-20	x				*			x					Y			H	N
Kidneywood	Eysenhardtia orthocarpa	18	25			x		*		x						N	NA			Y
Laurel, Bay	Laurus nobilis	12-25	12-25		x			*	*		x					N	L			Y
Mesquite, Argentine	Prosopis alba	20-30	20-30			x			*	x	x				*	Y	NA			N
Mesquite, Western Honey	Prosopis torreyana	25	30	x					*	x			*			Y		M		Y
Mesquite, Native	Prosopis juliflora	25	30	x					*	x			*			Y	L			N
Mesquite, Screwbean	Prosopis pubescens	15	20	x			*			x			*		*	Y		M		N
Mimosa Tree	Albizia julbrissen	15-25	25-35	x				*	*	x	x		*	*	*	N			H	N
Palm, Mediterranean	Chamaerops humilis	10-20	10-20		x		*				x			*	*	Y		M		Y
Palm, Pindo	Butia capitata	15-25	10-15		x		*				x			*	*	Y		M		Y
Palm, Windmill	Trachycarpus fortunei	10-20	6-10		x		*				x			*	*	N	NA			Y
Palo Verde, Foothill	Parkinsonia microphylla	10-20	10-20	x			*	*		x			*		*	Y		M		N
Palo Verde, Mexican	Parkinsonia aculeata	15-20	20-25	x					*	x	x		*	*	*	Y		M		N
Plum, Purple Leaf	Prunus cerasifera	15-25	15-25	x				*			x		*	*	*	N	NA			N
Pomegranate	Punica granatum	15-20	10-15	x				*	*		x		*	*	*	Y	NA			Y
Redbud, Eastern	Cercis canadensis	25	25	x				*			x					N	L			Y
Strawberry Tree	Arbutus unedo	8-30	10-30		x		*	*		x	x				*	N	L			N
Sumac, Prairie Flameleaf	Rhus lanceolata	12-20	15-20	x				*		x	x		*			N	L			N
Hackberry, Western	Celtis reticulata	15-20	15-20	x			*			x	x				*	N	L			Y
Texas Mountain Laurel	Sophora secundiflora	15	15		x		*	*		x	x					N	NA			Y
Xylosma	Xylosma congestum	10-15	10-15		x		*	*		x						Y		M		Y

Appendix A - Recommended Medium Trees

Common Name	Botanical Name	Height	Width	Tree Type			Growth Rate			Water Use			Litter			Spines or Thorns	BVOC			Parking Lots
				Deciduous	Evergreen	Semi-evergreen	Slow	Moderate	Fast	Low	Medium	High	Leaves	Flowers	Seeds/cones	Yes or No	Low	Medium	High	Yes or No
Acacia, Shoestring	Acacia stenophylla	40	30		x			*	*	x						N	L			Y
Acacia, Weeping	Acacia pendula	25-30	15-25		x			*	*	x				*	*	N		M		Y
Ash, Raywood	Fraxinus angustifolia	25-35	25	x				*	*		x	x	*			N	L			Y
Bottle Tree	Brachychiton populneus	30-50	30		x			*		x	x		*		*	N		NA		Y
Cherry, Carolina Laurel	Prunus caroliniana	25-40	15-25		x			*		x				*	*	N		NA		Y
Chitalpa	X Chitalpa tashkentensis	20-30	20-30	x				*		x	x		*	*		N		M		Y
Coolibah Tree	Eucalyptus microtheca	30-40	30-40		x			*		x	x				*	N			H	Y
Goldenrain Tree	Koelreuteria paniculata	20-35	25-40	x				*			x		*		*	N			H	Y
Japanese Pagoda Tree	Sophora japonica	30-50	30-50	x				*			x		*			N		NA		N
Locust, Honey	Gleditsia triacanthos	35	35	x				*			x		*		*	N		M		Y
Loquat	Eriobotyra japonica	20-30	30-35		x			*			x			*	*	N	L			N
Mesquite, Chilean	Prosopis chilensis	30	30			x			*	x	x		*			Y		NA		Y
Mesquite, Honey	Prosopis glandulosa	25-35	25-35	x					*	x			*		*	Y		M		Y
Oak, Chinquapin	Quercus muehlenbergia	30	30	x			*	*		x	x					N		NA		Y
Oak, Texas Red	Quercus buckleyi (texana)	25-30	25-30	x			*	*		x	x					N			H	Y
Olive, European fruitless	Olea europaea	30	30		x			*		x	x		*			N	L			Y
Olive, Swan Hill	Olea europaea 'Swan Hill'	20-30	20-30		x		*	*		x	x		*			N	L			Y
Palm, Mexican Blue	Brahea armata	20-40	10-15		x		*			x	x			*	*	Y		M		Y
Palo Verde, Desert Museum	Cercidium parkinsonian 'desert museum'	20-30	20-40			x			*	x	x			*		N		M		Y
Pear, Ornamental	Pyrus calleryana	30-50	20-30	x				*	*		x		*	*	*	N	L			N
Pepper, Brazilian	Schinus terebinthifolius	25-40	20-30		x		*	*		x					*	N		M		Y
Pepper, California	Schinus molle	25-40	25-40		x			*	*	x			*		*	N		M		Y
Pine, Chir	Pinus roxburghii	30-40	15-25		x		*	*			x				*	N		M		N
Pine, Japanese Black	Pinus thunbergiana	30-35	25-30		x			*	*	x	x				*	N		M		N
Privet, Glossy	Ligustrum lucidum	25-40	25-35		x			*			x			*	*	N		NA		Y
Sumac, African	Rhus lancea	20-30	20-35		x			*	*	x	x		*		*	N	L			Y
Texas Ebony	Ebanopsis ebano (Pithecellobium)	15-40	15-30			x	*	*		x						Y		NA		N
Texas Olive	Cordia boissieri	25-30	25			x	*	*			x					N		NA		Y
Yew Pine	Podocarpus macrophyllus	15-40	6-15		x		*	*		x	x					N	L			N

Appendix A - Recommended Large Trees

Common Name	Botanical Name	Height	Width	Tree Type			Growth Rate			Water Use			Litter			Spines or Thorns	BVOC			Parking Lots
				Deciduous	Evergreen	Semi-evergreen	Slow	Moderate	Fast	Low	Medium	High	Leaves	Flowers	Seeds/cones	Yes or No	Low	Medium	High	Yes or No
Ash, Arizona	Fraxinus velutina	30-60	30-40	x			*	*			x		*		*	N		M		Y
Ash, Fan-Tex	Fraxinus velutina 'Rio Grande'	50	30	x				*	*		x	x	*			N	L			Y
Ash, Modesto	Fraxinus velutina 'Glabra'	50	30	x				*	*		x	x	*			N	L			Y
Ash, Shamel	Fraxinus uhdei	40-80	15-60		x				*		x				*	N	L			Y
Blueberry, Japanese	Elaeocarpus decipiens	30-60	20-30		x			*			x				*	N		NA		Y
Cypress, Arizona	Cupressus glabra	50-70	10-15		x			*		x	x					N	L			Y
Cypress, Italian	Cupressus sempervirens	40-60	3-6		x			*		x	x					N	L			Y
Elm, Lacebark	Ulmus parvifolia	40-60	50+			x		*			x		*		*	N	L			Y
Hackberry, Common	Celtis occidentalis	45-80	40-50	x					*		x		*		*	N		NA		Y
Locust, Black	Robinia pseudoacacia	40	30-50	x				*	*		x		*			Y			H	N
Locust, 'Purple Robe'	Robinia x ambigua 'Purple Robe'	40	30	x				*	*		x		*	*		N		NA		Y
Magnolia, Southern	Magnolia grandiflora	60-80	30-40		x				*		x			*	*	N		NA		N
Oak, Cork	Quercus suber	30-60	30-60			x	*	*		x	x			*		N			H	Y
Oak, Escarpment	Quercus fusiformis	50	50		x			*	*	x	x					N			H	Y
Oak, Holly	Quercus ilex	30-60	30-60		x		*	*			x		*			N			H	Y
Oak, Live	Quercus virginiana	40-50	40-50		x		*	*			x	x	*		*	N			H	Y
Oak, Shumard Red	Quercus shumardii	55-80	40-50	x					*		x		*		*	N		NA		N
Oak, Valley	Quercus lobata	40-50	40-50	x				*			x	x	*		*	N		M		Y
Palm, California Fan	Washingtonia filifera	40-60	10-15		x		*	*		x				*	*	Y		M		Y
Palm, Canary Island Date	Phoenix canariensis	40-60	20-25		x		*				x			*	*	Y		M		Y
Palm, Date	Phoenix dactylifera	60-80	20-30		x		*			x	x			*	*	Y		M		Y
Palm, Mexican Fan	Washingtonia robusta	60-90	10-15		x			*	*		x			*	*	Y			H	Y
Pine, Aleppo	Pinus halepensis	30-60	20-40		x			*	*	x	x		*			N		M		Y
Pine, Mondel (Afghan Pine)	Pinus eldarica	30-60	15-25		x			*	*	x	x		*		*	N		M		Y
Pine, Stone	Pinus pinea	40-80	40-60		x		*	*			x		*		*	N		M		Y
Pistache, Chinese	Pistacia chinensis	50	50	x				*			x		*	*	*	N		M		Y
Sycamore	Plantanus occidentalis	75-90	50-75	x				*	*		x	x	*		*	N			H	N
Texas Umbrella (Chinaberry)	Melia azedarach	30-50	30	x				*	*	x	x		*		*	N	L			N
Zelkova, Japanese (Sawleaf)	Zelkova serrata	40-60	40-60	x			*	*			x	x	*		*	N	L			Y

Appendix B – Pervious Concrete

By David Akers, Senior Engineer, California Nevada Cement Promotion Council and Dan Huffman, Managing Director, National Resources, National Ready Mixed Concrete Association

The use of *pervious concrete* to control storm generated runoff started in Florida in the 1970s. In the intervening years, its deployment has been recognized by the U.S. Environmental Protection Agency as a "Best Management Practice." The cool community movement advocates *pervious concrete's* lighter color, ability to reflect solar heat, and other thermal properties as a means to reduce the *urban heat island*.

Pervious concrete in parking lots can be designed to capture storm water amounts ranging from "first flush" to major storms. As the captured water passes through the pavement and sub-grade, it is cleaned aerobically and by naturally occurring microbes and then replenishes the groundwater, enhancing the potentials for sustainability and *Low Impact Development*.

Often trees in parking areas have limited life due to improper design and installation. Numerous examples of tree lives being limited to seven years are known. Constructing *pervious concrete* parking lots, especially when desired near trees, allows moisture to infiltrate directly into the native soil and root systems, and along with available oxygen passing through the pavement, trees and other vegetation can flourish in an environment where otherwise they would not. *Pervious concrete* provides trees a healthy growing space.

Pervious concrete is used for new parking lots with new trees and as a retrofit to pave lots with heritage trees. Examples of the former type are Cottonwood Creek Park (Encinitas, CA) and Pine Avenue Park (Carlsbad, CA). The Fair Oaks Park District (near Sacramento, CA) replaced the gravel lot at Miller Park with a new *pervious concrete* lot saving all of the mature olive trees. The Vacaville, CA, police station was retrofitted with a *pervious concrete* parking lot that allows parking under the drip line of heritage oaks. It is calculated that the pervious installation annually returns 1.1 acre-feet of storm water to the ground water.

Since the 1960s, engineers, biologists, and environmentalists have recognized that urban runoff contains excessive organics, silts, metals, various chemicals, and especially *hydrocarbons* that are the primary pollutant contributors to surface and groundwater sources. Two primary physical impacts of higher flow rates and volume of urban runoff are increased downstream flooding and the erosion of stream banks. Further, urban runoff tends to increase "thermal pollution" (warming) which upsets the ecosystem by negatively impacting the natural habitat of many types of plants, fish, and other aquatics.

For additional information visit:
http://www.perviouspavement.org/
http://www.concretenetwork.com/pervious/
http://www.concreteparking.org/pervious/pervious.htm

Appendix C – Structural Soil

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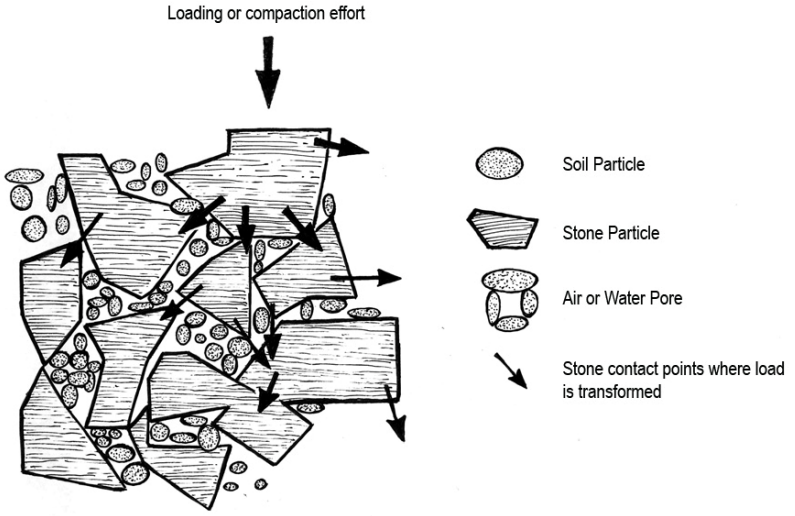
Structural soil mixes are two-phase systems comprised of a stone matrix for strength and soil for horticultural needs. *Structural soils* depend on a load-bearing stone lattice to support the pavement. The lattice provides stability through stone-to-stone contacts while providing interconnected voids for root penetration, air, and water movement. The friction between the stones provides the strength. A narrow particle size distribution of the stone is chosen to provide a uniform system of high porosity after compaction. The system assumes full compaction to construction standards. Angular stone is selected to increase the porosity of the compacted stone matrix. As the stone is the load-bearing component of the system, the aggregates should meet regional Department of Transportation aggregate soundness and durability requirements for pavement base aggregates.

The soil in the design mixture should be a loam to heavy clay loam, lacking in all but fine sands. The soil in the system will be present in small amounts so as not to interfere with the stone matrix. Organic materials are not used in modifying the soil for use in a *structural soil* system at this point, since they are generally avoided in normal pavement material selection. As a result, clay materials are needed for nutrient-holding and water-holding capacity. By carefully choosing the stone, soil and mixing ratio, we can create a gap-graded material able to provide the air and water balance necessary for root growth and plant establishment. The soil should also meet nutritional soil requirements for plant growth.

The objective is to partially fill the stone matrix voids with soil. The soil is meant to coat the stones and reside within the stone matrix. The compaction of the mixture would form the stone structure while the soil in between the stones remains largely non-compacted. The intention is to “suspend” the soil between the stones, which come together during compaction, producing a load-bearing, compacted stone matrix with un-compacted soil in the voids. When properly designed and compacted, the system will have large voids providing room for root growth and aeration of the root zone.

For additional information about structural soil visit: http://www.hort.cornell.edu/uhi/outreach/csc/



Appendix D – Soil Volume

Trees require adequate volumes of soil in which their roots can expand, allowing for tree growth. The amount of soil volume required by a tree varies with the species. An "adequate" volume of 920 cubic feet of healthy soil is recommended per square foot of tree *trunk* cross sectional area at diameter breast height (Kim D. Coder). This volume is calculated for the potential, future diameter of the tree, and not its current size. The minimum soil depth recommended for proper root growth is two to three feet – this is not to be confused with proper planting depth.

The table below provides some examples of the recommended soil surface areas for various sizes of mature trees, using the basic requirement of 920 cubic feet of healthy soil per square foot of tree cross sectional area.

Mature Tree DBH	Trunk Cross-sectional Area	Minimum Soil Volume (2.5 ft soil depth)	Minimum Soil Surface Area (2.5 ft soil depth)
6 inches	.2 ft^2	184 ft^3	74 ft^2 (8.5 ft x 8.5 ft)
12 inches	.8 ft^2	736 ft^3	294 ft^2 (17 ft x 17 ft)
24 inches	3.1 ft^2	2,852 ft^3	1,141 ft^2 (34 ft x 34 ft)

Recommended Soil Surface Areas and Volumes

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GLOSSARY

Abiotic - A nonliving factor or element in an environment such as light, water (flooding), heat, and gas.

American Forests - This group is the nation's oldest nonprofit citizens' conservation organization. American Forests is a world leader in planting trees for environmental restoration, a pioneer in the science and practice of urban forestry, and a primary communicator of the benefits of trees and forests.

American National Standards Institute (ANSI) - This entity produces standards for tree care practices, nursery production as well as other industries. American National Standards Institute, Inc., 1819 L Street, NW, Sixth Floor, Washington, D.C. 20036.

American Standard for Nursery Stock (Z60.1) - The standard for producing nursery stock including trees and shrubs.

ANSI A300 (Part 1 - 2001) Pruning Standard - *American National Standard for Tree Care Operations - Tree, Shrub, and Other Woody Plant Maintenance - Standard Practices (Pruning).*

ANSI A300 (Part 2 - 2004) Fertilization Standard - *American National Standard for Tree Care Operations - Tree, Shrub, and Other Woody Plant Maintenance - Standard Practices (Fertilization).*

ANSI Standard Z133.1 (2006) - *American National Standard for Arboricultural Operations - Pruning, Repairing, Maintaining, and Removing Trees, and Cutting Brush - Safety Requirements*.

Arborist - A professional trained in the care and management of trees. This position requires moderate to extensive education, experience, and certification in the field of *arboriculture*.

Arboriculture - The art, science, technology and business of tree care.

Biogenic Volatile Organic Compounds (BVOCs) - *Hydrocarbon* compounds from vegetation that exist in the ambient air and contribute to the formation of *smog*, or may themselves be toxic.

Biotic - Produced or caused by living organisms such as insects or disease pathogens.

Branch Bark Ridge - A raised area of bark tissue formed in the crotch at the union of two branches or at the union of a branch and the trunk.

Branch Collar - A "shoulder" or bulge formed at the base of a branch, where it joins trunk, by the annual production of overlapping layers of branch and stem tissues.

Caliche - A hardened deposit of calcium carbonate generally occurring in arid- or semi-arid regions. *Caliche* deposits can cause many problems when trying to grow plants.

Canopy - The forest layer formed by the leaves and branches of trees or shrubs. Small, medium, and large canopy size refers to mature tree size and not the size of the tree at the time of planting.

Canopy Cover - The percent of a fixed area covered by the *crown* of an individual tree or delimited by the vertical projection of its outermost perimeter including small openings in the *crown*. It is used to express the relative importance of individual species within a vegetation community or to express the coverage of woody species.

Carbon Dioxide - An atmospheric gas that plays an important role in the greenhouse effect. It also plays an important role in *photosynthesis*.

Certified Arborist - An individual who has passed the *International Society of Arboriculture* certification exam and maintains certification.

Chimney Tunnel - A hole or tube created in the bottom of a planting hole to ensure positive drainage through an impervious layer such as *caliche*.

Co-dominant - Forked branches that are nearly the same size in diameter, arising from a common junction and lacking a normal branch union.

Community Forest - See Urban Forest.

Critical Root Zone (CRZ) - The portion of a tree's root system essential to sustainability and survival. It is commonly calculated as the roots and soil within 1) the *dripline*, or 2) an area with a radius equivalent to the greater of 6 feet or 1.5 feet for every inch in *trunk* diameter at 4.5 feet above the ground.

Crown - The branches and foliage from the lowest branch to the top of a tree.

Crown Reduction Pruning - The selective pruning to decrease height and/or *crown* spread.

Diameter at Breast Height (DBH) - *Trunk* diameter measured at breast height, 4.5 feet above the ground on the uphill side (where applicable) of the tree.

Directional Pruning - Removing branches from a tree in such a way as to encourage new growth in a particular direction; this technique is usually applied to direct tree growth away from overhead conductors or other structures such as buildings or signs.

Dripline - The area underneath the tree crown, determined by the lateral extent of the foliage.

Girdling Root - A root that encircles all or part of the trunk of a tree or other roots, constricts the vascular tissue, and inhibits secondary growth and the movement of water and photosynthates.

Graft - The point of union where a detached bud, or shoot (scion) from a one plant is inserted into the shoot or root stock of a different growing plant.

Hydrocarbon - An organic compound that is released into the atmosphere as a result of incomplete combustion of fossil fuels and fuel evaporation. *Hydrocarbons* contribute to *ozone* and *smog* formation.

Included Bark - Bark that becomes embedded between a branch and the *trunk* or between two stems. This creates a structurally weak point in the tree.

Integrated Pest Management - A system of controlling pests and their damaging effects through the use of mechanical, chemical, biological, cultural, and regulatory techniques.

International Society of Arboriculture - An organization dedicated to the dissemination of knowledge of tree care and preservation based in Champaign, Illinois.

Landscape Architect - A registered professional trained in landscape planning and design.

Lateral Branch - A secondary branch growing from a larger limb (*parent branch*).

Low Impact Development - A comprehensive land planning and engineering design approach with a goal of maintaining and enhancing the pre-development hydrologic regime of urban and developing watersheds.

Monoculture - The growing of a single species. Monocultures are more vulnerable to impact by insect and disease infestation than are species-diverse forests.

Natural Target Pruning - Pruning techniques in which only branch tissue is removed, with the cut placed just beyond the *branch collar*.

Nitrogen Oxides (Oxides of Nitrogen, NO_x) - A general term pertaining to compounds of nitric acid (NO), nitrogen dioxide (NO_2), and other oxides of nitrogen. *Nitrogen oxides* are typically created during combustion processes, and are major contributors to *smog* formation and acid deposition. NO_2 may result in numerous adverse human health effects.

Ozone - A form of oxygen (0_3) produced when sunlight stimulates a reaction between pollutants. *Ozone* exists in the upper atmosphere *ozone* layer and at the earth's surface. Ground level *ozone* is the main ingredient of *smog* and can cause numerous adverse human health effects.

Parent Branch - A main branch or stem from which smaller *lateral branches* grow.

Particulate Matter - A form of air pollution resulting from airborne particles and that may affect human health.

Pervious Concrete - A concrete pavement that allows rainwater or irrigation to seep through the paved surface and into the soil.

Photosynthesis - The process in green plants of utilizing sunlight, *carbon dioxide*, and water to manufacture simple sugars for plant growth accompanied by the production of oxygen.

Planting Diamond - An area in the middle of a parking lot dedicated to a single tree. These areas are usually too small to provide sustainable growing space. A typical planting diamond is 4 ft. x 4 ft. in size.

Planting Island - An area in the middle of a parking lot dedicated to tree planting.

Planting Median - An area in the middle of a street dedicated to tree planting.

Prescription Fertilization - The philosophy of basing fertilization recommendations on plant needs determined by soil and tissue analysis.

Root Barriers - Items installed in the ground to direct root growth and roots into an area. Such devices could be constructed of plastic, metal, fabric or fabric impregnated with herbicides.

Rubber Sidewalks - Walkways made of ground recycled tires molded into squares.

Salt Index - An index used to compare the relative solubility of chemical compounds. Most nitrogen and potash compounds have high indexes and phosphate compounds have low indexes. Compounds with high indexes may cause damage to root systems.

Sequester - Annual net rate that a tree removes CO_2 from the atmosphere through the processes of *photosynthesis* and respiration (kg CO_2/tree/year).

Smog - A mixture of pollutants, principally ground-level *ozone*, produced by chemical reactions in the air involving *smog*-forming chemicals.

State Implementation Plan - A formal air quality management plan, produced by an individual state, specifying how state air resources will be managed to achieve federal and state standards.

Street Trees - Individual trees growing in rows within or directly adjacent to a street right-of-way.

Streetscape - The space between the street curb and the sidewalk reserved for planting trees but also shared with street lights and utilities.

Structural Soil - A medium for growing trees consisting of a load-bearing component, such as crushed rock, and a native soil component.

Sulfur Dioxide (SO_2) - A strong smelling, colorless gas that is formed by the combustion of fossil fuels. Power plants, which may use coal or oil high in sulfur content, can be major sources of SO_2. Sulfur oxides contribute to the problem of acid deposition, such as through acid rain.

Three-cut Method - A method by which large limbs are removed to prevent tearing of bark on the *trunk*. The method employs two cuts to remove the bulk of the limb and a third cut to remove the balance of the limb at the correct point for *natural target pruning*.

Topped, Topping - A pruning technique to reduce tree height by cutting back the *trunk* or large branches at indiscriminate locations. This is considered a poor pruning practice. Also known as dehorning, stub-cutting, lopping, hat-racking.

Transpire, Transpiration - The emission of water vapor through the stomata, microscopic openings in the surface of a leaf that allows gasses to pass in and out.

Trunk - The main woody axis of a tree.

Urban Forest - The trees and associated living organisms in an urban area.

Urban Forester - A professional trained in the management of the *urban forest*.

Urban Heat Island - An area in a city where summertime air temperatures are 3° to 8° F warmer than temperatures in the surrounding countryside. Urban areas are warmer for two reasons: 1) the use of dark construction materials for roofs and asphalt absorb solar energy and retain heat, and 2) few trees, shrubs or other vegetation exist to provide shade and cool the air.

Vertical Mulching - A technique to increase aeration of compacted soils, where holes are drilled into the ground and then coarse-textured or organic materials are added to replace the removed soil.

Volatile Organic Compounds (VOCs) - *Hydrocarbon* compounds that exist in the ambient air. VOCs contribute to the formation of *smog* and/or are toxic. VOCs often have an odor. Some examples are gasoline, alcohol, and the solvents used in paints.